THE

FIFTEENTH

ANNUAL REPORT

OF THE

Maryland

Agricultural Experiment Station.

COLLEGE PARK,

PRINCE GEORGE'S CO., MARYLAND.

1901-1902.

PUBLISHED BY THE STATION

The Maryland Agricultural Experiment Station

CORPORATION:

The Board of Trustees of the Maryland Agricultural College.

Agricultural (Station) Committee of the Board of Trustees.

GOVERNOR JOHN WALTER SMITH, (*Ex-Officio*) Annapolis.
CHARLES H. STANLEY (*Chairman*) .....Laurel.
CHARLES W. SLAGLE.....Baltimore.
DAVID SEIBERT.....Clear Spring.
MURRAY VANDIVER.....Havre de Grace.
CHAS. A. COUNCILMEN.....Glyndon.
ALLEN DODGE.....Washington, D. C.

Station Officers and Staff.

HARRY J. PATTERSON, B. S.....*Director and Chemist.*
JAMES S. ROBINSON.....*Horticulturist.*
SAMUEL S. BUCKLEY, D. V. S.....*Veterinarian.*
W. T. L. TALIAFERRO, B. A. .....*Agriculturist.*
CHAS. F. DOANE, M. S. Ag.....*Dairy Husbandry and Bacteriology.*
A. L. QUAINTANCE, M. S.....*Entomologist.*
J. P. S. NORTON, M. S.....*Botanist and Vegetable Pathologist.*
E. O. GARNER.....*Farm Superintendent and Recorder of Experiments.*
E. P. SANDSTEN, M. S.....*Associate Horticulturist.*
T. M. PRICE, M. S.....*Assistant Chemist.*
*F. P. VEITCH, M. S.....*Assistant on Soil Work.*
F. H. BLODGETT, M. S.....*Assistant Botanist.*
RALPH SMITH, B. S .....*Assistant Entomologist.*
JOS. R. OWENS, M. D. .....*Treasurer.*
B. H. GIBBS.....*Clerk.*
THOS. H. WHITE.....*Gardener.*

*Located with the Bureau of Soils, U. S. Department of Agriculture.

The Station is located on the B. & O. R. R. and City & Suburban Electric Car Line, 8 miles north of Washington, D. C.

BELL TELEPHONE—Washington Directory—Hyattsville 42.

Visitors will be welcomed at all times, and will be given every opportunity to inspect the work of the Station in all its departments.

The Bulletins and reports of the Station will be mailed regularly, free of charge, to all residents of the State who request it.

Address: AGRICULTURAL EXPERIMENT STATION,
College Park, Maryland.

LETTER OF TRANSMITTAL.

To His Excellency, John Walter Smith,

Governor, and President of the Board of Trustees,

Annapolis, Md.

Sir:—In accordance with the provisions of Section No. 3, of the Act of Congress, approved March 2nd, 1887, "To Establish Agricultural Experiment Stations," etc., I have the honor to transmit the Fifteenth Annual Report of the Maryland Experiment Station for the fiscal year ending June 30th, 1902.

Very respectfully yours,

H. J. PATTERSON,

July, 1902. Director of the Experiment Station.

THE MARYLAND

AGRICULTURAL EXPERIMENT STATION

VOLUME 15. 1901-1902.

THE FIFTEENTH ANNUAL REPORT.

For the Fiscal Year, July 1, 1901, to June 30, 1902.

By the Director.

The duties imposed upon an agricultural experiment station are quite comprehensive and varied, yet, there is one point which is commonly overlooked by the general public, which, in a measure, circumscribes the work and functions of the station. The law, while giving a range of subject for consideration, yet specifically designates that the station shall conduct researches or experiments bearing directly upon the agricultural industry of the United States. Section 2, of the Hatch Act, defines the work and it is as follows:

"That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments in the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and waters; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different foods for domestic animals; the scientific and economic questions involved in the production of butter and cheese, and such other researches or experiments bearing directly on the agricultural industry of the United States, as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective States or territories."

Wide as is the range of work designated by this law, yet there are many things which it seems desirable to do so as to bring the work of the Station in touch with the people and in order to conform to public demands, though it is not strictly research. All who have had to do with the practical working of an experiment station recognize

that it is necessary to conform in a measure to the popular demands and notions of the practical farmers.

The demands for information of a character which has long passed the experimental stage by letter, by lecturers at farmers' meetings of various kinds, and by visit to individul farms is constantly on the increase. This class of work draws heavily upon the time of the investigators and considerably lessens the amount of new information that can be acquired. Nevertheless it is deemed necessary for the Station to include this field of labor within its province and the only way that the full demands may be met will be to have the State provide for the expense incurred and so not encroach on the proper expenditure of the "Hatch" fund. As to the work in progress at this Station, it may be said in general that all has gone smoothly and that everyone connected with the Station has seemingly put forth their best efforts towards advancing the best interests of the Station as a whole, as well as the particular division with which they are concerned.

LIST OF EXPERIMENTS IN PROGRESS.

It is impossible to give an adequate idea of the work at the Experiment Station and its several divisions, by an enumeration of the same within the space of a brief report. To fully appreciate the tests in progress and the amount of labor involved by the different tests, it is desirable to go over them in detail with the specialist in charge; but, as this is impossible for many, the lines of investigations being pursued by the several divisions are briefly enumerated in the following pages. The principal lines of work may be classified under the following heads:

AGRICULTURAL DIVISION.

1. Agricultural grasses and legumes; comparison of thirty-two varieties, as to their adaptation to local, climatic and soil conditions, productiveness, longevity, aggressiveness, time of development and special usefulness for hay or pasture. Begun in fall of 1899.

2. Experiment to determine the best method of using stable manure as to time and manner of application—twenty plots. Begun in fall of 1899. Duplicate experiments begun in summer of 1900.

3. Experiment to determine the best method of cultivating corn. Begun in spring of 1900.

4. Experiment to determine the best time for planting field corn. Begun in spring of 1900.

5. Experiment to determine the comparative value of thick, medium thick and thin planting of corn.

6. Experiment to determine the best method of applying commercial fertilizers to corn in connection with stable manure.

7. Experiment to determine the effect of different methods of planting, cultivating and manuring corn upon the stand and develop-

ment of crimson clover following corn. This experiment follows experiments 2 to 6, inclusive.

8. Experiment to determine the relative value of first and second crop seed potatoes. Begun in 1900, continued in 1901.

9. Experiment to determine the best method of cultivating potatoes. Begun in 1900, continued in 1901.

10. Experiment to determine the practicability of growing cowpeas with corn. Begun in 1900, continued in 1901.

11. Experiment to determine the effect of early and late turning under of crimson clover as preparation for late potatoes. Begun in fall of 1900.

12. Experiment to determine the hardiness of fall-seeded alfalfa. Begun in fall of 1900.

13. Experiment in inoculating soil for soy beans. Begun in fall of 1900.

14. Experiment in improvement of wheat by selection of seed. Begun in 1898.

Besides the experiments mentioned above this division takes part in some of the cooperative tests with the United States Department of Agriculture and with numerous farmers in the State.

DIVISION OF BOTANY AND PLANT PATHOLOGY.

Most of the time of this division is taken up with the inspection work necessitated by the State Horticultural Inspection law; but aside from this some special investigations are in progress upon the following subjects:

1. Peach yellows.
2. Peach rot.
3. Apple rot.
4. Cantaloupe blight.
5. Crown gall of apple.
6. Cabbage diseases.
7. Root Diseases of fruit trees.
8. Diseases of green house crops.
9. Cooperative experiments, in several parts of the State, spraying for the prevention of fruit and vegetable diseases.

CHEMICAL DIVISION.

The chemical division has had considerable routine work to perform during the past year in connection with the experiments of other divisions and the examination of miscellaneous samples; but, besides this work, much time has been spent in cooperation with the dairy division upon a study of the effects of milk preservatives upon digestibility. At the present time a study is in progress upon the effects of various kinds of baking powders upon the digestibility of breads.

DAIRY DIVISION.

The most of the past year the dairy division has been occupied in conjunction with the chemical division in the study of the influence of milk preservatives upon digestibility. Besides this work the following experiments are in progress:

1. Conditions which effect the keeping qualities of milk.
2. Methods for the control of the moisture content of butter.
3. Testing and trying to devise methods for removing garlic odors from milk and butter.

DIVISION OF ENTOMOLOGY.

This division, as well as the division of plant pathology, is chiefly concerned with the inspections necessitated by the State Horticultural Inspection Law and most of the time of the Entomologist is consumed in this work. The lines of the work pursued may be classified under three main heads.

1. Experimental work in orchards with various insecticides for the better control of the San Jose Scale. The past winter, rather extensive experiments have been conducted in various parts of the State with different strengths of crude petroleum and with lime, salt and sulphur wash. Results as far as determined indicate that the lime, salt and sulphur wash, is practically as effective in killing the scale as the mineral oils, or whale oil soap, even under adverse weather conditions. Arsenate of lead, in various strengths, is being tested on peaches and plums as a possible remedy for the curculio.

2. Life history studies of injurious insects are being conducted in the laboratory as much as time will permit. At the present time the habits and life histories of the following species are under investigation: The black peach aphis, (Aphis persicae-niger); the West Indian peach scale (Diaspis pentagona); the curculio (Contracpelus nenupher). Some time is given during trips over the State to collect data on the various injurious species of insects, and this information is properly classified in the office and thus becomes available for future ready reference.

3. A permanent collection of economic insects of the State has been begun, which, it is hoped to make of great value and interest. So far as possible the various life stages are represented with specimens of their work. Such a collection will be very valuable in our own work and will also be available for illustration purposes at agricultural and horticultural meetings.

HORTICULTURAL DIVISION.

The work of this division during the past year has been considerably interfered with by the sickness of Prof. Robinson, since the first part of August, 1901, and this made the work devolve upon Prof. Sandsten, the associate horticulturist, who came to us just a few days

before Prof. Robinson was taken sick. This condition, as can be well understood, placed Prof. Sandsten at considerable disadvantage. Prof. Sandsten was also sick for a number of weeks in the early winter with typhoid fever, which placed him at still further disadvantage in his new field of labor, and prevented taking up some work which might have been possible otherwise.

The gardener, Mr. White, followed the routine work of the department, so that this part has suffered very little.

Considerable new work has been outlined and inaugurated the present year, and the whole of the work is being classified and rearranged so as to make all more systematic and enable the labor to be better and more economically performed. Much of this has been made a necessity at this time by the transfer of the garden and campus to the Experiment Station, so that all can be supervised and conducted with the same force.

The lines of work in the horticultural division for the present may be briefly summarized as follows:

1. Experiments along the line of orchard management, including cultural methods, spraying, cover crops, pruning and the use of fertilizers.

2. Tests of varieties of apples as to their adaptability to Maryland climate and soils.

3. Cooperative experiments in the use of cover crops as to their relative value in different parts of the fruit-growing sections of the State.

4. Cooperative tests as to the relative value of muriate and sulphate of potash on apples, peaches, pears and plums.

5. Extended study as to the cause or causes which produce pithiness in celery and to compare the relative merits of foreign and domestic celery seed.

6. Extended variety tests of strawberries, melons and tomatoes.

7. Extended study of different kinds of greenhouse soils.

8. Extended cooperative tests of varieties of sweet potatoes in connection with the United States Department of Agriculture.

9. A study of the best variety and cultural methods of currants, gooseberries and raspberries.

10. Plant breeding and selection with strawberries and carnations.

11. Best rotation of vegetables for forcing in greenhouses, and test of varieties for indoor culture.

12. Onion growing, cultural methods and variety test.

13. A systematic study of the different fruit areas of Maryland and conditions which influence them.

VETERINARY DIVISION.

The work of the veterinary department of the Experiment Station for the past year has been devoted to a consideration of the disease among horses known as Leucoencephalitis. Attempts have been made to induce this disease by feeding and by inoculation, but so far without any degree of success.

Throughout the year several calves have died with peculiar symptoms, that have recently been shown by Nocard to be the result of the same agency. It is that of "White Scour" and "Lung Disease." Previously, this has been slow to respond to treatment, as its real cause was unknown. It has been proven to be due to the entrance of microorganisms, at, or shortly after, birth, through the "navel-cord," and the two diseases, although dissimilar, are due to the same agency. Proper treatment at the act of birth has prevented these diseases, and it will be done hereafter in our animals. There seems to be no question about our trouble being identical with that reported upon by Nocard in April, and a test is under way at the present time.

Several cases of sickness have occurred during the year, and several operations performed on our animals. On the outside a few cases of Parturient Paresis (Milk Fever) have responded to the Schmidt treatment.

The entire dairy herd has been Tuberculin tested and eleven cases responded to the test. Two of these were destroyed, and showed well advanced cases of Tuberculosis. The remainder have been isolated for experimental purposes, and this work will be taken up at once. It is intended to make periodic injections of Tuberculin to study its effect, in way of verifying such tests made heretofore, and to determine the value of Cinnamic Acid or Cinnimate of Soda in producing encrysted tuberculas nodules. This is now claiming the attention of human specialists, and is deserving of careful inquiry, as its results seem to be very hopeful. For our purposes the crude Benzoin and Balsam Storax and Peru can be used as being less expensive, and a certain amount of which is already on hand. These contain Cinnamic Acid, and possess properties additionally beneficial.

It is to be hoped that nothing will prevent a careful study of Bovine Tuberculosis in our isolated herd. Fortunately, beyond the ordinary care of these animals the expenses of experimental work need be but slight. The rearing of calves can be made a source of profit from this herd, provided their disease runs a slow course, and provided the calves are removed immediately after birth. This use of Tuberculous animals has been made in Denmark at the suggestion of Prof. Bang, and is successful.

Finally, the stable has been thoroughly cleansed and sprayed with disinfectants, so that the chances of further infection are slight.

COOPERATIVE EXPERIMENTS.

This Station has in progress at the present time cooperative experiments with the U. S. Department of Agriculture upon the following subjects:

1st. Cooperative investigations upon cereals, which embrace the improvement of the quality of wheat, barley and other grains. Producing varieties better adapted to the region and otherwise making them more valuable, particularly as regards the time of maturing yielding power, disease resisting and quality of the grain.

2. Cooperative grass and forage plant investigations, which has particularly in hand the working out of a scheme of soiling crops which will not only give an abundance of green roughage for as great a portion of the year as possible, but also for determining the best means of always having available a combination of leguminous and graminaceous crops.

3. Cooperative investigations upon the influence of the origin of clover seed on the yield of the crop.

4. Cooperation with the Division of Chemistry in testing the effects of locality upon the quality of wheat.

5. Cooperative experiments on variety and culture tests of sweet potatoes.

6. Cooperative tests of different varieties of foreign apples and peaches.

7. Cooperation with the Division of Soils.

8. Cooperative tests upon foreign varieties of melons.

Besides the cooperative work with the U. S. Dept. of Agriculture, the Station has in progress numerous cooperative experiments with farmers of the State, the principal ones of which are as follows:

1. Tests at several points in every county of the State in growing alfalfa.

2. Work in the improvement of corn, as to quality and quantity, by selection.

3. Culture tests with corn.

4. Tests in spraying for control of insect pests.

5. Tests in spraying fruits and vegetables for the control of plant diseases.

6. Tests of varieties of fruits in different sections.

PUBLICATIONS.

During the past year the following bulletins have been issued:

No. 77.—The Comparative Digestibility of Raw, Pasteurized and Cooked Milk, by C. F. Doane and Thos. M. Price.

No. 78.—The Dehorning of Stock, by C. F. Doane.

No. 79.—The Disinfectant Properties of Washing Powders, by C. F. Doane.

No. 80.—Acute Exizootic Leucoencephalitis in Horses, by Dr. S. S. Buckley.

No. 81.—Soils and Fertilizers for Green-house Crops, by H. J. Patterson and Thos. H. White.

No. 82.—The Thinning of Fruit, by E. P. Sandsten.

No. 83.—An inquiry as to the Cause of Pithiness in Celery, by E. P. Sandsten and Thos. H. White.

No. 84.—Some Experiments in Dairy Feeding, by H. J. Patterson.

MAILING LIST.

The general mailing list has had about 1,500 names added during the past year, and the horticultural list has been increased by about 2,000 names. These additions have mostly come through special letters requesting the bulletins, which indicates that the value of these bulletins is being recognized, and shows an increased interest in the work of our institution.

VISITORS.

The number of farmers who come to the Station to look over the work and observe the results of experiments is constantly increasing. There are but few days that pass without someone visiting the institution, either for the purpose of seeing the work as a whole, or with the object of getting information on some special subject. This is gratifying to all concerned. The annual visit of the farmers' organization is constantly increasing in popularity, as is evidenced by the numerous inquiries that are made many months ahead as to what day will be named, and the larger numbers which visit us on these days. This year there was over three hundred present. The committee of the delegates appointed to look over the work of the Station and make a report to the main body, reported as follows:

To the Farmers of the State:—

At a meeting of the delegates sent by twenty-five farmers' organizations of the State of Maryland, held at Maryland Agricultural College on 28th day of May, 1902, the following gentlemen were named as a committee of investigation for the enlightenment of the farmers of the State:

August Stabler, M. D., Montgomery County; Joseph T. Hoopes, Harford County; M. C. Reeder, Cecil County; Henry Fuss, Carroll County; James B. Ensor, Baltimore County.

After a tour of inspection and ample opportunity for investigation the committee met and adopted, unanimously, the following report:

The buildings and personnel of the institutions have impressed us most favorably. The Experiment Station now, as in the past, is a great and ever increasingly valuable source of new and practical suggestions to the farmers who come here, or who read the bulletins that are sent out to 10,000 farmers of the State. The work is admirably systematized and arranged, and we hope that more money will be given it from the State Treasury in the future than in the past; for

we are sure that it will not be misspent by the faithful men in charge of these most valuable lines of investigation. An enormous correspondence is carried on between the farmers and the Station. A half of every day is given by the Director in answering letters. It would take two men's time constantly occupied to answer all the letters.

We note that there is still much land on the Experiment Station farm that is badly in need of underdraining. This being regarded as a permanent improvement cannot be done with the U. S. fund, and should be provided for by the State, for experiments on such land are of little value till it is drained. (Signed by the Committee.)

STATION STAFF.

Since making the last report there has been no changes in the Station staff, except that two vacancies have been filled by the appointment of F. H. Blodgett, M. S., as Assistant Plant Pathologist, and Ralph Smith, B. S., Assistant Entomologist. These men are chiefly concerned with the work of the State Horticultural Department.

BUILDINGS.

During the past year a new house for the herdsman and quarters for the apprentices have been built. This drew pretty heavily upon the Station funds, but has supplied a much-needed addition.

The round barn is now undergoing some renovation and remodelling in order to make better facilities for handling hay, etc., and also to enlarge the storage capacity, as last year the barns were all full, and considerable straw and fodder had to be stacked.

All the buildings need painting, and some other repairs, which it is hoped may be thoroughly done during the next fiscal year.

THE FARM.

The work on the farm is becoming more and more contributary to the experiments in progress. The yields which are being obtained from those parts devoted to the regular rotation are quite satisfactory, and attract much attention on the part of visitors. Last summer a very considerable quantity of hay was made, so that there is enough left over from last year's crop to carry the present stock another season, besides selling more than $100.00 worth. The present season has been unusually dry, and hay crops generally will be very short. Even with this condition there has already been made about one and one-half tons per acre from the twenty-two acres set to orchard grass and clover the fall of 1900.

NEW LEGISLATION.

The bill passed by the last Legislature in the interest of the College and Station had one section that will materially benefit the Experiment Station, and enable it to properly care for the building and

broaden its sphere of usefulness. The section reads as follows:

"Section 5. In order to provide for the maintenance, repairs and insurance of the buildings of the Experiment Station, to provide for printing of the bulletins and making exhibits, showing the results of the work; also to provide for investigations on the tobacco crop, in meat production, and irrigation, an annual appropriation of five thousand dollars ($5,000.00) is hereby provided for and made."

This fund will become available for the first time October 1st, 1902.

STATION LIBRARY.

It would seem wise at this time to call special attention to the Station Library, its present condition and future needs.

The Station Library is partially located in the main Station building, while other parts are scattered in the private offices of the heads of the several divisions. In all cases, the Library is in crowded quarters, which do not admit of much expansion and growth. This condition also makes many of the books not as accessible to all the workers as is desirable, particularly so with that class of books and periodicals which treat of many subjects. To make this condition still more serious none of the Library is catalogued, so that much of the information which should be easily accessible in the library of an institution of this character, it takes often a considerable time to find just what is wanted, and, no doubt, often overlooked entirely.

At present the Library is looked after by the Clerk at such times as he is not engaged upon the other special duties for which he is employed. This is also not as it should be, for a library to be in proper shape needs someone with special training and library proclivities to look after it constantly, so that that which is already on hand may be in the best of shape for ready reference, and also that the library may be kept up-to-date with the new books, pamphlets, etc., which are constantly appearing. Especially to keep track of and procure those issued by the U. S. Department, State and many foreign countries, which can be had for the asking.

The College Library is in about the same chaotic condition as the Station Library. This being the case, and the great importance which a library is to the College for educational purposes, and to the Station as an investigation facility, it would seem very desirable that some provision be made for a good, commodious and well-arranged building conveniently located for the accommodation of the Station and College Libraries, and that a well-trained librarian be employed, so that the material on hand be well classified, indexed and catalogued, and so that it will be someone's business to look after keeping the library together and in proper shape, and make it a point of keeping the library in all of its divisions up-to-date.

It would be a very fitting, as well as a lasting, monument for some of the men of this State who have made fortunes directly from the immense agricultural resources of this country to provide and endow a

library which would be used exclusively for the furtherance of agricultural education and development.

AGRICULTURAL MUSEUM AND EXHIBITS.

The necessity for a well-equipped museum representing the agricultural capabilities of this State is brought to our attention by the great national exhibitions which are being frequently held, at which the resources of the several States and countries are being exhibited to the world. Maryland is relatively not behind the foremost of her sister States in agicultural production, and in some things she need bow her head to none, and yet she has not at hand an exhibit for use on such occasions worthy of her position and resources as a producing State. It is manifestly impossible to prepare a good representative exhibit in a single year. Even the collecting of an ordinary exhibit in a short space of time means that a considerable amount of money must be provided, and an extra amount of energy applied. The appropriation granted this Station by the last Legislature permits of the expenditure of some money for making exhibits showing the results of the Station work at the county fairs. These exhibits, so far as possible, will be made of a permanent character. If, however, this Station exhibit could be supplemented annually by a moderate sum of money for the furtherance of an agricultural museum, very soon the State would have an exhibit of which she would not need to be ashamed.

A modern museum in agriculture should not be a place for the mere piling up of material in order to fill space or exhibiting products calculated only to excite wonder. It should be educational in its purpose rather than spectacular. To multiply bushels of grain or tons of vegetables, or the arranging of sheaves of wheat in fantastic form has little educational value. Baltimore or Washington city markets will show all of this any day in the year.

The full aim in preparing the Station exhibits for the county fairs will be to make them of an educational character, and while in the main they will show the results of experiments they will be supplementary to as great an extent as possible towards the dissemination of the advanced scientific knowledge of agriculture, and exhibit the results of the application of this knowledge in producing crops.

For instance, in making an exhibit of corn the fundamental principles surrounding that plant should be brought out, and all that is known about it. The exhibit should show the plant in all its stages of growth. The grain, the flower, the roots, the products made from it as they are put on the market and used; the chemical constitution as it relates to its food value. The soil as it is adapted to its culture, and the effects of physical and chemical characteristics of the soil as they relate to the growth and constitution of corn. The fungous diseases that affect the crop, and the insects which attack it should be shown. Fertilizers that are adapted to the growth of the crop and the effects of temperature, rain-fall, sunshine, humidity and any other facts which have an influence upon the production of the crop will be brought out.

Methods of improvement by breeding and selection will be dwelt upon.

Such an exhibit will become a study, and will be worth the time and attention of any man, woman or child interested in knowing the best way to cultivate or manufacture this cereal.

The idea expressed in the above may be developed indefinitely, and carried through with a variety of products, and if properly prepared, arranged and explained will be worth more to the farming public than all of the big pumpkins and loads of products usually heaped upon the tables at the county agricultural fairs.

The plan will be to have the Station exhibits placed in portable cases so that they can be preserved from year to year, and serve to interest and instruct agricultural people for a generation to come, and always be available for shipment to any part of the county where its presence is desired.

The suggestions given for plans for the Station exhibits could be elaborated, if means were available, to ultimately make a fine and representative exhibit for the State, which could be used whenever and wherever the State desires to make an exhibit at some of the great national fairs to which she is constantly receiving invitations to participate. Such a plan would be much more economical than those commonly in vogue, and give the State a creditable exhibit, which would not only be always available, but could, also, with a small cost for a permanent home at the College, be a perpetual source of education to the youth of the State, and to the many thousands of people who visit the Experiment Station.

Again, the adoption of this plan by the State would be the first step toward the renovation and reorganization of the so-called State agricultural fair, and enable this organization to divorce itself from the trotting associations, and put forth its full energies for the development of the agricultural resources of the State.

An ideal State agicultural fair association should be centrally located and have a permanent home. The exhibits should be purely of an agricultural and educational value.

In addition to the general exhibits the different countries should have county buildings and county exhibits, and compete for county prizes. The judging should be done in the arena and in public, so that those interested could be instructed as to the points of excellence, and thus be made as instructive as possible. In addition to the fair and its exhibits there should be an aim to have all the breeding, horticultural and other associations have meetings during the fair, and there should be held at this time a special farmers' institute, where it could be possible to give lectures of a character and given by people whom it would be impossible to take over the State in the regular system.

Such a State fair could be productive of an immense amount of good, and would bring about a great agricultural awakening in Maryland, and it would not necessarily interfere with the present county agricultural associations, but in some cases would allow them to concentrate their efforts upon what is now the strongest feature, and also make them in a measure serve as a preparing ground for the State fair.

WEATHER REPORT.

The weather for the growing season of 1901 was excessively wet, which made much of the work to be done with difficulty. Haying was attended by many interruptions, and the quality of much of the hay injured by rain, and some got more mature than is desirable. Corn was not properly cultivated, as land, in some instances, was too wet. The late potato crop was in some spots entirely drowned out, and others considerably reduced. This dry growing season was followed by a dry fall and early winter, which prevented the fall seeded grain from coming up well, or getting a proper start. This condition was followed by the hardest and most unfavorable winter for crops since the organization of the Experiment Station, in 1888. The following is the meteorological summary:

METEOROLOGICAL SUMMARY FOR 1901.

Temperatures in Degrees.

(FAHRENHEIT).

Month.	Precipitation.	Temperatures—Mean.				Extreme Maximum.	Extreme Minimum.
		Daily Mean.	Maximum.	Minimum.	Daily Range.	Record and Date.	Record and Date.
January....	1.75	31.8	40.7	23.2	17.5	64, 9th and 16th.	0, 31st
February..	.90	27.9	38.7	17.1	21.6	57, 16th	7, 1st and 24th
March.....	3.53	44.1	56.0	32.3	23.7	76, 19th	6, 6th
April.....	6.40	50.0	59.6	40.4	19.2	84, 30th	31, 27th
May	4.17	62.6	76.1	49.2	26.9	85, 24th	36, 13th
June	6.72	70.4	84.7	56.2	28.5	99, 30th	47, 8th
July	5.38	78.9	90.7	67.1	23.6	102, 1st	61, 10th
August.....	4.93	74.6	85.5	63.8	21.7	97, 8th	55, 31st
September.	3.69	65.2	76.2	54.2	22.0	90, 15th	37, 26th
October	1.47	56.8	72.0	41.9	30.1	83, 23rd	25, 25th and 26th
November..	2.78	39.1	50.9	27.3	23.6	69, 1st	14, 20th
December..	6.70	31.1	41.0	21.2	19.8	65, 2nd	2, 22nd
Yearly.....	49.42	52.2	64.3	41.1	23.2	102, July 1st.	0, January 31st.

FINANCIAL SUPPORT.

The financial support of the Station is derived entirely from the United States Hatch fund, and the small amount which comes from the sale of farm products. The State of Maryland has contributed nothing toward the support of the Experiment Station, and whatever of value the farmers of the State have received from the Station has come to them without any cost to themselves or to the State.

The Legislature which met the past winter has supplemented the Station income by making provisions for an annual appropriation of five thousand dollars. This will become available for the first time October 1st, 1902. For exact wording of law see page xii.

The Treasurer's Report for the fiscal year ending June 30th, 1902, is as follows:

Maryland Agricultural Experiment Station in Account With the United States Appropriation.

1902. DR.

June 30	To Receipts from the Treasurer of the United States as per appropriation for the fiscal year ended June 30, 1902, as per Act of Congress Approved March 2, 1887	$15,000.00

1902. CR.

June 30	By Salaries	8,025.64
"	Labor	2,690.52
"	Publications	671.85
"	Postage and Stationery	105.30
"	Freight and Express	100.00
"	Heat, Light and Water	341.70
"	Chemical Supplies	206.89
"	Seeds, Plants and Sundry Supplies	468.03
"	Fertilizers	100.83
"	Feeding Stuffs	241.68
"	Library	358.93
"	Tools, Implements and Machinery	505.80
"	Furniture and Fixtures	191.08
"	Scientific Apparatus	97.40
"	Live Stock	64.93
"	Traveling Expenses	64.42
"	Contingent Expenses	15.00
"	Buildings and Repairs	750.00
		$15,000 00

The above is a true copy. (Signed) JOS. R. OWENS,

Treasurer Maryland Agricultural Expt. Station.

Maryland Agricultural Experiment Station in Account With the Station Farm.

DR.

1902.		
June 30—To receipts from other sources than the United States during the fiscal year ended June 30, 1902, viz:		
To Cash Balance July 1st, 1901		$ 723.34
To Cash from Farm Sales		4,808.89
		$5,532.23

CR.

1902.	
June 30—By Labor	1,782.99
" Freight and Express	382.26
" Seeds, Plants	452.00
" Fertilizers	128.00
" Feeding Stuffs	1,400.00
" Tools, Implements and Machinery	500.00
" Contingent Expenses	123.47
" Buildings and Repairs	743.11
" Balance	20.40
	$5,532.23

The above is a true copy. (Signed) JOS. R. OWENS,

Treasurer Maryland Agricultural Expt. Station.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 77. AUGUST, 1901.

THE COMPARATIVE DIGESTIBILITY OF RAW, PASTEURIZED AND COOKED MILK.

By C. F. Doane and T. M. Price.

INTRODUCTION.

The authors are equally responsible for the general plan of the experiments given in this bulletin and both had an equal part in looking after the details of the work and the designing and necessary trials of the apparatus used in what is practically a new line of work for experimenters in this country. In all of the planning, however, we had the benefit of the advice of Director H. J. Patterson, whose experience in digestive work proved invaluable in this work, and whose judgment was constantly consulted. The dairyman had direct oversight of the feeding and cooking and the bacteriological work which needed to be done in connection with the pasteurizing. The assistant chemist did all the chemical work and made the necessary calculations for the tables included in this bulletin.

These experiments were planned for the purpose of determining as nearly as possible with the material at hand, the comparative digestibility of raw, pasteurized and cooked or what is sometimes wrongly called sterilized milk. When the germ theory of disease had become almost universally accepted, and the science of bacteriology had come to aid in the investigation of the cause of many of the diseases to which the human family is heir, it was universally recognized how easily many of them could be transmitted through the milk to the human subject. Tuberculosis in its relation to milk received more attention at first than any of the other diseases, as both the cow and the human family were afflicted with this disease, and it was supposed to be identical in both subjects. Tuberculis germs were found in the milk coming from the cow's udder, and in this way might enter the human system. The properties of cow's milk were studied and it was found to be an excellent food for bacteria, and also furnished a medium where bacteria being once introduced could multiply very rapidly. This was seen to be an easy way for the spread of contagious diseases caused by bacteria, as a single case of disease in the family of the farmer supplying milk for the city consumption could easily be carried to every customer using this milk. In many cases the supply of milk from a number of sources is mixed together to insure an even quality. If there is one lot of con-

taminated milk among the lots mixed together the whole mass is contaminated. The seeds of the disease can be distributed in this way to dozens of families dependent upon the country supply of milk. There have been numerous instances of such cases, and some of the worst typhoid epidemics recorded have been traced to the home of some farmer producing milk for the city consumption where a member of the family was suffering with this disease, the typhoid germs finding their way into the milk, usually through the water used in washing the cans. The milk supply, even now, when so much is known in regard to the methods of supplying a good product, is one of the most fertile causes of disease; and when a local epidemic of typhoid fever is found in a city where the water supply comes from a common source, the milk used by those suffering with the disease is the first thing investigated.

As the study of bacteriological questions progressed it was found that the milk fresh from the udder of a healthy cow was practically free from germs, either harmless or harmful. A study of the milk delivered to the city trade showed it to have from a few thousand bacteria to the cubic centimeter in a few cases, to several million germs to the cubic centimeter in the majority of cases. Milk fresh from the udder af the cow is recognized to be the very best, especially for infants. But milk cannot be delivered fresh in cities, as after or during the milking it is utterly impossible to exclude all bacteria from the buckets or cans, and these bacteria, which find their way into the milk, multiply very rapidly under the ordinary conditions The greater number of these germs are entirely harmless, but a few which are always present in milk are now universially regarded as aggravating causes of summer complaint in infants and they cause a great amount of sickness and a large number of deaths among the children of the hot tenement districts. It is likely, also, that such germs lead to considerable sickness among children more favorably located.

Considering the frequency of the contamination of milk, it became a question among physicians how all disease germs in the milk could be killed, and a majority of the other germs either killed or excluded. No harmless chemicals had been or have been discovered which will effectually sterilize or preserve milk by killing germs present or preventing their rapid increase in numbers. It was found that this end could be attained by heating, and the natural result followed, that heat was employed, usually at the boiling point. So great was the need of some remedy that this plan spread rapidly and was adopted by many of the leading authorities on diatetics. The usual plan advised, was to put the milk in bottles, plug the necks with cotton, and then put the bottles in boiling water for from fifteen minutes to one-half hour. The size of the bottle was such as to hold enough milk for one feeding of the child. It is questionable if the rapidity of the adoption of the use of milk thus treated was not a little abnormal, for it seems that it was adopted without much thought as to the possible evil consequences this treatment might have, for even at that time cooking milk was known to change to some extent its physical properties. Many who used this boiled or cooked milk did not know how to regulate the

heating, and seemed to have ill-defined ideas as to the methods of carrying out the process. In some instances the milk was not heated sufficiently to affect the contained bacteria and when this was kept for any length of time it became unfit for use unknown to the user. In other cases the milk was heated every time before using, yet there were some people who supposed that milk once heated would keep indefinitely. All this confusion led to a large number of bad results. Scurvy, rickets and indigestion occurred and so pronounced were the evil effects in some cases that almost a complete reaction followed in the use of milk thus treated. Now very little cooked milk is used in any place. Physicians had so much trouble with it that they are very careful in its use, though a number believe that some children cannot only drink it without suffering any evil in consequence, but are actually benefited by its use.

Though physicians found that boiled milk gave rise to more trouble than the milk which had not been subjected to this high temperature, they still recognized the fact that milk sometimes contained disease germs, and always contained germs which increased summer complaint in infants. They were consequently constantly searching for something which would kill these germs and not injure the milk in other ways. There are many who believe that pasteurizing practically fulfills these conditions. Pasteurizing is a process in which the milk or other liquid to be treated is heated to a certain temperature below boiling for a certain period of time. The limits of the temperature and time is regulated by the minimum amount of heat required to kill the germ causing consumption on the one hand and the amount required to give milk a cooked taste on the other. Milk can be heated to 140 degrees F. for thirty minutes, 150 degrees F. for fifteen minutes, 167 degrees F. for ten minutes or 182 degrees F. for from two to four minutes without giving it a permanent decidedly cooked taste, and at these temperatures for the periods of time given all tuberculous germs are killed. The heat used in pasteurizing does not kill all the germs in the milk, but it materially reduces the number, and milk so treated will keep enough longer than raw milk to insure its reaching the consumer in a healthy condition, as far as the bacteria are concerned. While heat has been employed in this process the milk does not have some of the physical characteristics of the boiled milk. Pasteurized milk is advocated by many physicians for use by children, and it is in almost universal use in some of the children's hospitals. It is also condemned by many physicians, and the objections offered against its use are much the same as those urged against the use of boiled or cooked milk. They say that infants fed on pasteurized milk do not thrive as well as those fed on raw milk, and the somewhat natural conclusion was reached that the reason for this was because it was not as digestible as the raw milk. This, perhaps, is the most serious, if not the only reason advanced.

The claim that pasteurized or sterilized milk was not as digestible as raw milk must be admitted to have been founded largely on

prejudice or unsystematic observation, as there have been but very few experiments made to determine the comparative digestibility of raw and pasteurized milk, either with artificial or animal digestion. Raw milk is and always has been, the natural food of the mammalian young, but while this is good evidence in favor of the wholesomeness of raw milk, it is no proof that it is better for the young than pasteurized or boiled milk would be. The natural food of the young is the milk fresh from the breast of the mother, but the milk upon which the young children in cities are forced to subsist is far on the road to decomposition and has much in it, especially bacteria, which the fresh product does not have. The question confronting the physician of today is, even admitting that pasteurizing or boiling gives the milk undesirable qualities which have an evil effect on the consumer, does not the pasteurizing or the boiling have good results which more than compensate for the evil? To actually study the effect of pasteurizing or boiling on the digestibility of milk it is necessary to carry out some set plan of experiments, where the composition, both of the original product and the resulting product can actually be determined. This in a measure can be done by employing artificial means. When considering the adaptability of milk to the nourishment of animals, especially infants, the best plan would obviously be to feed a known quantity to the infant and collect and analyze the faeces. Unfortunately those who are in a position where the subjects for such an experiment would be available, either do not have the time or the apparatus for the necessary analytical work required. Next to the infant, the most satisfactory subject for such an experiment would be some young animal which would be sensitive to any change in its food supply. While workers in experiment stations are not in a position to avail themselves of infants for such work, a choice of animals can be had.

A number of very prominent pediatrists and other scientists interested in dairy matters have recognized the importance of exact knowledge of the digestibility of milk under varying conditions and a few have tried in a limited degree, to investigate the question and supply the need. The work which has actually been done can be classified under three heads, that done with artificial ferments, experiments with animals and experiments carried out in two instances only with children. Part of the work, perhaps the greater part has been done in Europe, especially in France and Germany, but the most important experiment of all with children was carried out with infants in a New York hospital. The proximity of this Station to the Department of Agriculture at Washington made it possible for us to use the extensive library located there and as it contains all foreign publications we had access to all literature concerning the question upon which we were working. We found that while there has been considerable written on the question and published in French and German journals, most of the literature was based upon a comparatively few experiments which have been discussed by different writers from a number of standpoints in a number of distinct articles. The experiments on which these articles were based were carried out before the pasteuriz-

ation of milk became universal and they compare mostly the digestibility of raw with boiled or sterilized milk.

De Jagers, (Diet. and Hyg. Gaz., Vol. 12., 1896, pp 281,) compared the digestibility of raw with cooked milk, using pepsin and lactic acid in his work. He came to the conclusion that the raw milk was the more easily digested.

Jemma, (Hyg. Gaz. Vol. 16, 1900, No. 2, pp 83,) employed artificial digestion in comparing the digestibility of raw with sterilized milk. He made a number of experiments and concluded at the end that sterilizing did not impair the digestibility of the milk.

EXPERIMENTS IN ARTIFICIAL DIGESTION.

Michael, (Hyg. Rund, 1899,) conducted a number of experiments in artificial digestion using in one case pepsin in hydrochloric acid. When allowed to digest for eight hours a leiter of raw milk had 18.75 grams of peptone, while a leiter of sterilized milk had but 17.53 grams of peptone after the same period of time. In another case he used pancreatin in neutral solution. At the end of five hours the raw milk had 21.76 grams of peptone and the sterilized milk 24.64 grams, which leaves a wide margin in favor of the sterilized milk. In still another trial where the casein of the milk was first precipitated by rennet the raw milk digested quicker than the sterilized. While Michael found that with the use of pepsin in hydrochloric acid raw milk showed a greater per cent of protein digested after a number of hours, the sterilized milk showed a greater per cent. digested for the first three hours. At the end of this short period of time raw milk showed but 9.59 grams of peptone to the leiter while sterilized milk showed 11.32 grams. The final conclusion is that sterilization does not lessen the digestibility of milk.

Fleischmann compared the digestibility of raw milk with milk sterilized at a pressure of from two to three atmospheres. He took 10 cc of milk to be digested and 10cc of ten per cent solution of pepsin and .2 cc of a twenty per cent solution of hydrochloric acid, allowing the digesting to continue for five and one-half hours. In a series of experiments he came to the conclusion that sterilized milk is more easily acted upon by digestive ferments than raw milk.

From the work done in artificial digestion there seems to be a wide diversity of opinons drawn from what is really widely different results. To sum up the conclusion briefly, one, De Jagers, came to the conclusion that boiling or sterilizing milk made it less digestible. Jemma and Michael agreed in the opinion that sterilizing did not impair the digestibility of milk, and one, Fleischmann, who stands at the very head of scientific dairymen, emphatically stated that sterilizing made milk more easily digested. A review of the work done by Michael leaves one with the impression that he was too conservative in his conclusions as his results given in figures showing the amount of milk digested in the given times seem to lean a little in favor of the sterilized milk. This leaves the decision decidedly in favor of the ster-

ilized milk, but as was stated before while results obtained by artificial digestion are valuable they are not positive proof of what would be the results if the same feed was given to animals or children.

EXPERIMENTS WITH ANIMALS.

In addition to the work done in artificial digestion we have the record of two separate experiments with feeding either pasteurized or sterilized milk to animals in comparison with raw milk. H. H. Dean, (Ontaro Agr. Col. and Expt. Farm Report, 1898, pp 166,) reports an experiment in which raw milk and pasteurized milk was fed to four calves to compare the feeding value. No chemical analysis was made either of the milk or the faeces to determine the actual digestibility of either of the lots of milk fed. The calves were weighed at the beginning and at the end of the experiments to determine the relative gain. This is the method usually pursued to determine the comparative feeding value of different lots of feed and the results thus obtained are accepted in many cases as conclusive. The tests made by Dean covered two periods of four weeks each, previous to which the calves used in the experiment were fed a preliminary period of one week. In the first period two of the calves received raw milk with grain and hay, and the other two calves received pasteurized milk with the same quantities of grain and hay. In the second period the two calves receiving raw milk in the first were fed pasteurized milk, and the other two received raw milk. Three of the calves used made the heaviest gains while receiving pasteurized milk. A further test was made in which eight calves were used, four in each lot. In this experiment the four calves receiving pasteurized milk made a gain of 110 pounds, while the four receiving raw milk gained 105 pounds, five pounds in favor of the pasteurized milk.

The other experiment carried out with animals was with dogs, the work being done by M. Raudnitz, (Zeitsch for Physiol. Chem.) He carried out three separate experiments with the same dog in which he compared the digestibility of raw and sterilized milk, the experiments varying considerably in time. With the first the dog was growing, in the second he had reached his full growth, and with the third the dog, for some reason, appeared to be losing weight. The following tables show the amount of nitrogen and fat undigested in the three experiments:

TABLE 1.

Per Cent. of Nitrogen Undigested.

	1st Expt.	2nd Expt.	3rd Expt.
Raw milk,	12.3	13.3	13.0
Sterilized milk,	13.6	18.6	16.0

TABLE 2.

Per Cent. of Fat Undigested.

	2nd. Expt.	3rd Expt.
Raw milk,	4.4	5.6
Sterilized milk,	6.2	4.1

EXPERIMENT WITH CHILDREN.

As far as we are able to discover but two men have ever carried on any experiments in feeding raw, pasteurized and sterilized milk to children or infants with the idea of collecting and making an analysis of the faeces to determine the relative digestibility of the milk when treated in these different ways. Bendix, (Ann. Inst. Pasteur, Vol. 9, 1895, pps. 362 to 365) compared boiled milk with milk sterilized at 115 degrees C. under pressure. He fed this milk to children about two and one-half years of age, feeding a known quantity of milk with a known quantity of other simple foods, mainly bread. He sums up the results of his work in the following tables:

TABLE 3.

Per Cent. of Nitrogen Undigested.

	1st Expt.	2nd Expt.	3rd Expt.
Boiled milk,	15.3	8.5	7.6
Sterilized milk,	15.7	9.1	7.0

TABLE 4.

Per Cent. Fat Undigested.

	1st Expt.	2nd Expt.	3rd Expt.
Boiled milk,	9.1	8.8	6.4
Sterilized milk,	8.9	9.0	5.1

Two of these experiments were in favor of the greater digestibility of the boiled milk, though the difference was very small and might be well calculated to be within the limits of error in the analyses. DuClaux who reviewed these experiments in the Ann. Inst., Pasteur, entered in to some sweeping criticism of Bendix's work because he did not extend his investigations to include raw and pasteurized milk, as the uncertainty was in regard to the comparative value of milk under these conditions rather than with boiled and sterilized milk. The work of Bendix was of considerable scientific value but fell short of the practical value which it would have possessed had the work included raw and pasteurized milk.

The most valuable and best planned and executed series of experiments with the digestibility of raw, pasteurized and boiled milk of which we have been able to find any account were conducted under the direction of Dr. Henry Koplik, attending physician to the Good Samartian Hospital of New York, and also in charge of the children's ward of Mt. Sinai Hospital of the same city. The results of this work were published in the New York Medical Journal and a reprint has been published by the author in pamphlet form. There is considerable material in this published report aside from the actual records of the experiments conducted which is of value. Dr. Koplik has made a study from all sides of the digestibility of milk and he gives some interesting ideas of the use of it under varying conditions. Some of this material will be given later. Dr. Koplik's first experiments were with a couple of children who were receiving a part of their food from the

breast of the mother. These will not be considered. His next experiments were with two boys, one aged three months and the other aged five months. To the first he fed pasteurized and then sterilized, then raw milk. This child was not in good health, though it was not suffering from any digestive disturbances. The second infant he gave milk brought to a boil in comparison with milk sterilized at 100 degrees C. Each experiment covered a period of seven days. The results of his work can be seen in the following table:

TABLE 5.

	Nitrogen taken in milk.	Nitrogen remaining in faeces.
First Infant.—	grams.	per cent.
Pasteurized milk, ...	10,9209	4.6
Sterilized milk, ...	13.7449	4.9
Raw milk, ...	5.3914	3.4
Second Infant.—		
Boiled milk, ...	32.643	4.5
Sterilized milk, ...	30.969	4.3

In this series of experiments the raw milk was fed but four days as it was found that though the work was conducted in the winter the milk would sometimes sour before it was used. While the first infant used was not in good health, Dr. Koplik considered that the last experiments were conducted with a child which was in perfect condition. The tables show that while there was very little difference in the digestibility of the different lots of milk fed, the little difference was in favor of the raw milk. The plan of experiments show two elements of weakness. The same quantity of milk was not fed during the different periods and there was a lack of repetition. As a rule in digestion experiments, three trials with as many subjects is considered the minimum number that will give conclusive results. In the feeding of young infants so many elements may enter in to cause serious variation, that it seems as though even more than the regulation three trials would be desired.

As any digestion experiments in which food intended for the use of children is fed to animals to obtain comparative results, would leave a margin for doubt as to the physical action of such foods upon the infant health, it was thought that the opinions of physicians who have had actual experience in children's nurseries and hospitals would go far towards supplying what could not be shown by the chemical analysis or the resulting effect of the food on the health of the calves used. It is entirely possible that while pasteurizing or sterilizing milk could render it more easily digested when fed for a short period to infants, the heat used in treating the milk might give it other qualities which would cause it to be injurious to the health of the child receiving it. Physicians having in charge a large number of infants would be very likely to notice this if it were the case, so it was determined to obtain, if possible, the written opinion of a number of such

men in the leading cities of this country. The names of these men were furnished by Dr. W. D. Booker of Johns Hopkins University and a personal letter was addressed to each man explaining the character of the work we were doing and what we wished from them. We received prompt and courteous replies to our requests, and these letters are herewith given with such alterations as are necessary to be used in this connection.

Dr. L. Emmett Holt, of New York, writes as follows:—

My experience is that heating to as high a point as 167 degrees F., interferes to a slight degree, at least, with the digestibility of milk, and this is increased the higher the temperature of the milk is raised and the longer the period it is continued. Clean, raw milk, properly handled is the thing most to be desired. The dangers from contaminated milk in the summer are so much greater than those of heated milk that I am inclined during that season, to advise that all milk used for infant feeding be heated.

Dr. John Zahorsky, attending physician to the Bethesda Foundling Home and Episcopal Orphan's Home of St. Louis for five years, in introducing the following points, says: There is still much to be learned about the use of milk as a feed for infants. I summarize my observations as follows:

1. The exclusive use of sterilized milk does not prevent gastro-enteric disease. Infection of the alimentary canal may take place by contagion as may other infectious diseases. There have been two such epidemics in the Bethesda Home.

2. Rickets occur in infants fed on sterilized milk in much greater percentage. When fed on raw milk about 15 per cent. of the babies have rickets well marked. On sterilized milk and other foods our percentage was about 50 to 75.

3. Marasmus is less liable to occur when raw milk is used. The last two years we have been using raw milk exclusively and have had only one case of marasmus among four hundred infants admitted. On sterilized milk a larger percentage of such cases occurred.

4. Scurvy is liable to occur among infants fed on sterilized milk. I have never seen one case among those fed on raw milk.

5. Infants fed on sterilized milk are markedly deficient in those physical activities which overcome infectious diseases. These infants succomb to gastro-enteric disease, pneumonia, influenza and other infectious diseases in much greater proportion. Our mortality at the Foundling Home has been reduced 15 per cent since we fed infants on pure, clean raw milk.

A few explanations of terms used by Dr. Zahorsky may help some of the readers. Marasmus is a term used to describe a condition of infants in which the food taken does not seem to have the proper nourishing effect on the body which gradually wastes away. Rachitis or rickets is applied to a condition in which the bones do not have sufficient mineral matter to give them the proper firmnesss.

Dr. J. P. Crozer Griffith, of Philadelphia, who is connected with two hospitals in Philadelphia, writes as follows:

In general I believe that the digestibility of milk is often interfered with by either pasteurizing or sterilizing, but I by no means share the decided prejudice that many have against these processes. I believe that in the mass of cases the absence of heating does much more harm than the heating does. Where, however, I can get milk upon which I can well depend, I prefer to use it raw as a rule. This is the result of my experience both in private and in hospital practice. In both the children's hospital of this city we pasteurized the milk because we can not trust it raw.

Dr. John Lovett Morse, of Boston, Mass., who has charge of the infant's hospital, writes the following letter:

I have had no experience in the use of sterilized milk. I have, however, had considerable experience in feeding milk pasteurized at 167 degrees and at 155 degrees, as well as with raw milk. Judging from clinical observations, as to vomiting, number of dejections, their character and the presence of curds, I feel that there is no difference in the digestibility of pasteurized and raw milk. I feel pretty certain, however, that children do not thrive so well on milk heated at 155 or 167 degrees F., as they do on raw milk. On the average they are not as vigorous, do not gain in weight as fast and are more likely to become anaemic and rachitic.

Dr. Henry Koplik, of New York, in reply to the inquiry addressed to him, sent a short letter and also the pamphlet containing some digestive work done by himself, an abstract of which has already been given. In his letter he refers to some things given in the published report which come better in this connection than with the previous abstract. He writes as follows:

"Soon after the presentation of the sterilization of milk, it was generally adopted. It was seen that the procedure was welcomed by the infant and certain serious gastro-intestinal disorders, common to infancy in the summer, were more easily controlled by its use. Those of us whose experience antedates the introduction of sterilization would be first to realize the loss to infancy were we today deprived of its use. The cases of marasmus brought forward by certain men as a proof of starvation from the use of sterilized milk were seen and still are seen in places and institutions where the sterilization of milk is unknown. In other words, the cause of starvation in these infants must be a deeper seated one than that seized upon by writers to prove their position. Huebner, while still working in Leipsic, showed that there was an actual increase in the weight of infants on an exclusive diet of sterilized milk. He thought this necessary to stem the tide of distrust awakened against one of the greatest advances in the management of artificially fed infants. He does not deny that there are certain cases coming under the head of marasmus which the sterilization of milk and its modification will not reach, but he shows, however, from actual statistics that a very large percentage of the cases of chronic intestinal disorders of a variety incurable before the introduction of sterilized milk are improved and cured by the same. The shortcomings of sterilized milk is not all a matter of the heating to the

degree of sterilization, but is a matter, perhaps, inherent in the nature of the food itself. Experts now realize that the subject of the digestibility of cow's milk is something deeper than its method of heating. There are so many factors which enter into this matter that the heating alone is only a small part of them. The caseine, its nature as compared to human milk, the nucleins of cow's milk as compared to human milk, the methods of dilution of cow's milk, their predigestion for some infants are all of vast and over-reaching importance when compared to the question of the heating of the milk. If an infant does not increase in weight no amount of raw or pasteurized milk as compared to sterilized milk will cause an improvement."

A personal visit was paid by one of the authors to Dr. W. B. Platt, who is in charge of the Robert Garrett Hospital for children in Baltimore. He says that a few years ago sterilized milk was fed to all the children in the hospital, but this was discontinued as the children did not appear to thrive as well as when the raw milk was used. Pasteurized modified milk is now fed to all the infants in the hospitals during the summer, and to special cases during the winter. Dr. Platt said that if he could get absolutely pure milk for the children he would prefer it raw in all cases, but owing to the impossibility of obtaining such milk he was forced to pasteurize though he did not believe that children fed pasteurized milk thrived as well as when fed perfectly pure raw milk.

A visit was paid to the Nursery and Child's Hospital of Baltimore. It was learned that about four years ago sterilized milk was fed to all the children in the hospital, but as the children did not thrive and there was more illness at this time, the sterilized milk was discontinued for raw milk. An inquiry led to the opinion that the process of sterilization adopted at this institution was rather irregular, which might have accounted for the unfavorable results.

These communications from the heads of the children's hospitals of the country show them, with one exception, (Dr. Henry Koplik, of New York,) to be opposed to the use of cooked or sterilized milk as a food for infants on the grounds: first, because the children do not thrive as well when it is fed, and secondly, because they claim that its use leads to marasmus, rickets and scurvey. One of the physicians, Dr. John Zahorsky of St. Louis, in his reply advocates the use of raw milk and from his reply we would infer that he would always use it under every condition normal to city hospitals. The other physicians are in favor of raw milk where it can be obtained in a pure, clean condition, but they recognize the impossibility of obtaining such milk in the summer so they advise pasteurizing, believing it to be the less of two evils. It seems to be the common opinion of the physicians that heating milk injures it for infant use, and the higher the heat to which the milk is subjected the more pronounced the injurious effects; but at the same time a majority of them believe that most unheated milk has certain injurious properties which can in a measure, be remedied by heating. The question with them seems to be, which, under varying conditions, is the least harmful, the unpasteurized milk with its multi-

tude of injurious germs or the same milk minus the germs, but with certain other properties which are objectionable. To determine just the effects of pasteurizing milk, especially as regards its digestibility, is what we wanted to do in the work taken up at this station. The physicians corresponded with without exception unite in saying that there is much about cow's milk as a food for children yet to be learned. What is often given as facts seems in many cases to be a matter of opinion made up from impressions gained largely through superficial observation, and it is likely, that in some cases at least, prejudice enters largely into reasoning. Only two of the physicians in replying to our inquiry gave statistics or results of work actually recorded, and it will be noted that these two are widely at variance in their respective conclusions. This certainly shows a lack of definite knowledge, and in a matter of so great importance all agree in saying that there is much to be learned.

Anyone who has had experience with feeding calves and understands their nature and the quickness with which they show the effect of any serious change in their food would recognize their peculiar fitness for such experiments as we desired to make. The milk of the cow fresh from the udder is, of course, the natural food for the young calf. Any physical change in the milk would be likely to be shown by the calf very quickly, especially as young calves are very susceptible to any change for the worse in their food and show usually by scouring and sometimes by refusing their food that something is wrong. Knowing these particular characteristics, we chose calves rather than any other available animal for these particular experiments. We think that the results have justified our choice and met our expectations.

In taking up this work it has not been our plan to enter upon any elaborate discussion of the use of milk as food or into any theory of the changes in milk caused by heating it, though such changes undoubtedly occur. Neither do we feel qualified to discuss with any degree of completeness, the effect of the milk used in these experiments on the physical health of the animal. But this effect as far as it is obvious to one feeding calves will be noted with each separate experiment. We merely desired to study as far as it was possible and practicable with us, the comparative digestibility of milk under the conditions named with what we supposed were the best animals to be used.

This experiment is, as far as we have been able to discover, the first digestion work which has ever been done with young calves. This made it necessary to design our own apparatus. To collect the faeces it was necessary to confine the calf in a standing position for the required period, and a receptacle in which to collect the faeces was patterned. As the calves were light and could easily be lifted around by two men a crate was considered to be the best way of confinement. It was supposed that by making the crate narrow the calf would be forced to stand up while kept in it. But young calves necessarily spend much of their time lying down and the crate could not be arranged to force the calf to remain on its feet for the necessary period.

Figure 1.—Showing method of slinging calf in crate.

Figure 2.—Rear view of calf in crate.

Figure 3.—Bag for collecting faeces.

They would invariably sink to the bottom almost as soon as they were put in, and acted so restless that something else was necessary. To meet this difficulty, holes for their four legs were cut in a large bran sack. Nails were driven in the tops of boards on either side of the crate and the sack was swung from the nails just high enough to allow the calf's feet to rest firmly on the floor. This gave the calves a chance to settle down in a crude swing and still keep in position to collect the faeces. This plan worked perfectly and apparently kept them from becoming in the least fatigued. All of the calves used availed themselves of the opportunity to rest by settling down in this sack. The general plan can be seen to advantage in figures 1 and 2. With few exceptions we had little trouble with calves so confined. They could jump out, but only two persisted in doing this so that they could not be used in the experiment. As the calves made a gain of weight in a majority of the trials we must conclude that they felt comfortable in the crate.

Figure 3 shows the sack-shaped receptacle used for collecting the faeces. It was made from thin white rubber cloth and was in two pieces, the shape of which can be judged by the seams on the sack. The calf's tail was put through a small hole and the two upper strings were passed forward and tied in a cloth collar placed around the neck. The two lower strings passed between the hind legs and fastened one on either side of the calf to the cloth collar placed on the neck. This sack worked very satisfactoryily and even when the faeces were thin it retained every particle. This sack was changed every morning, the contents weighed and the sack washed and dried after a sample of the faeces has been taken for analysis. Figure 2 gives some idea as to the way the sack was fitted to the calf.

While conducting these experiments the calf was not allowed to have a particle of food other than the milk given. For a time they were prevented from eating by being confiend in a pen with a bare floor, but as the cold weather was coming on the bare cement caused considerable discomfort. Warmer and more comfortable quarters were provided by muzzling the calf and allowing it to be turned into a pen with other calves where plenty of straw was given for bedding. The muzzle was designed and made at the station from small, pliable wire and mosquito netting. This was removed when the calf was fed and worked very satisfactorily, causing no apparent discomfort and entirely preventing the calf from eating straw.

It was the general plan to feed the calves in every case through a preliminary period of three days as this was thought to be sufficient to allow all milk previously fed to pass through the digestive tract. In cases where the calf had received straw before commencing on the preliminary period, no collections were made until all cellular tissue had ceased passing with the faeces. The calf was then confined in the crate and the faeces were collected for three days. A week is usually allowed for collecting the faeces in each period in digestive experiments, but we were afraid that the additional time would be too long for the calf to stand in the crate. Mature cattle or horses can stand

for weeks at a time without showing any apparent discomfort, but it was evident that the younger calves used in our experiments could not stand for a week without becoming so fatigued as to militate against the value of the work. Even the three days the calves were kept in the crate appeared to tell on the strength of some of the younger ones used, and had it not been for the sack placed under them which allowed them to virtually lie down, though in an unnatural position, the work would have lost much of its value.

In feeding the calves the quantity of milk given was adjusted to about what the average calf would require for moderate growth. This with the younger calves would, of course, be less than the same calf would need a month older, but we desired to feed a uniform quantity under all conditions and to all of the calves used. About sixteen pounds or a little less than two gallons was at first decided to be about the right amount. But as our work progressed it seemed that this amount was too much for the younger calves and caused scouring. The quantity was then reduced, and even with this less amount a number of the calves made substantial gains in weight while confined in the crate. All of the milk fed to the calves was from two cows of the herd. This milk was taken in the morning, the amount from both cows mixed together and a sample taken for fat and protein determination. The calves were fed morning and evening from this morning's milk. We thought that the milk from two cows would be preferable to milk taken promiscuously from the mixed milk from the entire herd, as our herd has an average test of about five per cent. which we considered above the average in fat. Then, too, we have no facilities for mixing the amount of milk received from an entire herd and that selected might have been from one lot of cows one morning and from an entirely different lot the next morning. The two cows selected were chosen for their relatively low test which averaged about 4 per cent., and because they were heavy and persistent milkers, which insured a sufficient quantity for two calves through the entire season. Few, if any, cities have a milk standard as high as 4.2 per cent. of fat, and it is doubtful if much milk testing higher than this amount is sold to the ordinary city trade. Had we selected mixed milk from a half dozen cows instead of two, as we did, we would have had the advantage of less variation in composition, but during the time we were carrying on this work the milk was fairly regular in its fat and protein content. On the other hand the mixed milk from a number of cows is supposed to be less digestible or to have a more undesirable effect on the animal stomach than that from one or two cows.

The calves were fed about 8.30 in morning, and about 6.00 in the evening. This made the periods a little irregular, which we deplored, but which could not be avoided. The variation in feeding periods was the same in all cases.

In this work the health of the calf as far as could be seen was carefully noted and with one exception no calf which did not appear to be perfectly healthy was used. A number which showed signs of weakness or sickness after we had commenced on the preliminary

period were not used, the feeding being discontinued until the calf had regained its normal health or another calf was substituted. No faeces were collected from calves which were scouring. During the year we had considerable trouble with calves scouring at different times, and quite often they would start after they had been placed in the crates. In a couple on instances where the calf did not commence to scour until the last day it was to be kept in the crate, we allowed the two first days to serve as a basis for calculating the results of the work and did not save the faeces the last day. In other cases of scouring where the calf commenced to scour during the preliminary period or when first placed in the crate, the experiment was discontinued until the calf was well, when we started on the preliminary period again. We regarded this tendency to scour as favorable to our work rather than otherwise, as the calf's stomach responded to anything wrong with its food more quickly than it would had the calf been in a state of perfect health.

The general plan of the work was to feed first the raw milk, then the pasteurized milk, then the cooked milk, using the same calf with each one, and in a couple of cases repeating the series with the same calf. In repeating the series with the same calf the advanced age of the calf offered some objection as it was then getting to the age when they desired to eat some coarse fodder, and it seemed to worry a few of them because they could not do this. The calves in nearly every case were used for the experiments when about two weeks old. By this time their digestion of the milk given would have become regular, they were young, and any thing wrong with the feed would be more likely to be shown, both in physical appearance and in the analysis of the faeces, and this allowed the calf to gain a little strength to be confined in the crate. The raw milk was given fresh in the morning from the mixed milk from two cows as was before noted. Part of this was put away to be fed in the evening. The milk to be pasteurized was taken from the same cows. We decided to pasteurize at 167 degree F. for ten minutes. As this was a medium temperature between the extremes usually used for pasteurizing, 155 degrees for twenty minutes or 182 degrees for from two to four minutes. As pasteurizing milk at 140 degrees for thirty minutes has been found by Russell and Farrington (16th Ann. Rpt., Wis. Expt. Sta.) to have less effect on the physical properties of the milk, some separate experiments were carried on with milk heated to this temperature. For pasteurizing we improvised our own apparatus using a shotgun can and a barrel of water connected with steam. The milk was given frequent stirrings during the process. As soon as the milk had remained at the high temperature for the necessary length of time it was run over a cooler. This is a little unusual, as of course a large number of germs would gain access to the milk during the operation. But we did not care to have the milk keep for any unusual length of time, all milk being fed the same day it was milked. The physical changes in the milk rather than the bacteriological was what we desired, and we made no unusual effort to exclude germs after the milk

had been heated. The presence of germs in moderate numbers may or may not influence the digestibility of the milk, but that was a question upon which we did not care to enter. We preferred the milk with about its usual number of bacteria and differing from the raw product only as the heat of pasteurizing had affected its organic constituents. The cooked milk was heated in the same way as the pasteurized milk, but in this case the milk was heated from 185 degrees F. to 190 degrees F., where it was allowed to remain over a half hour. It was then cooled rapidly by setting it in cold running water. This milk while it had not been boiled had all the appearance of boiled milk and had a decidedly cooked flavor. It is likely that the half hour's heating to 185 degrees cooked the milk as thoroughly as boiling for five minutes would have done. A number of bacteriological analyses were made in the pasteurized milk to determine the efficiency of the work done from that standpoint, but no analysis was made of the cooked milk. It was undoubtedly practically sterile, although it is well understood that heating to the temperature of 185 degrees for a half-hour will in some cases leave a few spores with sufficient vitality to grow as soon as the normal conditions of temperature are restored. We did not care for sterile milk. The physical effect of the heat on the organic constituents of the milk being what was desired as was the case with the pasteurized milk. No effort was made to introduce the normal number of bacteria into the milk after it had been cooked, but no effort was made to keep them from the milk. It is likely that by the time the calf was fed at night the milk which had been heated had almost as many germs as though it had not been heated.

The following tables, 6 and 7, gives the composition of the milk fed in the different experiments, and also of the faeces collected. The per cent. of water given is only approximate as no exact analyses were made. Tables given the average composition of milk for given amounts of protein and fat were used and the per cent. of water was taken from this. The analyses of the samples can be identified with the experiments by the index numbers which are the same as in the tables recording the details of the experiments. In the analytical work the Babcock test was used for determining the amount of fat in the milk.

TABLE 6.

COMPOSITION OF MILK USED IN THE FOLLOWING EXPERIMENTS.

Index No.	Description of samples.	Water per cent.	Protein per cent.	Fat per cent.
2313	Whole Milk, raw	88.00	3.16	3.20
2334	" " pasteurized	88.00	3.12	3.30
2345	" " raw	87.00	3.03	3.70
2353	" " "	87.00	3.06	3.80
2363	" " pasteurized	87.00	3.10	3.60
2372	" " "	87.00	3.10	3.70
2382	" " raw	86.50	3.21	4.20
2391	" " "	86.50	3.17	4.00
2400	" " pasteurized	86.50	3.36	4.00
2409	" " "	86.50	3.25	4.30
2416	" " cooked	86.50	3.35	4.00
2422	" " "	86.50	3.47	4.10
2434	" " raw	86.50	3.52	4.40
2441	" " "	86.50	3.41	4.20
2449	" " pasteurized	86.50	3.40	4.20
2462	" " "	86.50	3.40	4.10
2469	" " cooked	87.00	3.20	3.80
2481	Skimmed milk	90.50	3.45	Trace
2488	" "	90.50	3.40	"
2494	" "	90.50	3.24	"
2552	Whole milk, raw	86.50	3.42	4.00
2555	" " "	86.50	3.30	4.10
2560	" " pasteurized	86.50	3.15	4.00
2568	" " "	86.50	3.34	4.00

TABLE 7.

COMPOSITION OF FAECES COLLECTED IN DIGESTIVE EXPERIMENTS.

Index No.	Description of samples.	Water, per cent.	Protein, per cent.	Fat, per cent.
2322	Calf 1—Fed whole raw milk	66.22	6.36	4.89
2334	" 1— " pasteurized milk	80.99	6.06	2.70
2351	" 2— " whole raw milk	88.81	2.62	1.35
2359	" 1— " " " "	62.08	8.90	3.85
2369	" 2— " pasteurized milk	74.70	5.34	3.72
2378	" 1— " " "	86.13	2.44	.86
2388	" 3— " whole raw milk	75.80	6.73	3.28
2397	" 2— " " " "	78.20	3.63	2.58
2407	" 3— " pasteurized milk	83.24	3.71	2.51
2415	" 2— " " "	78.04	2.81	2.00
2425	" 3— " cooked milk	77.66	4.71	1.2[illegible]
2433	" 2— " " "	72.30	4.56	2.32
2440	" 4— " whole raw milk	75.32	2.07	1.53
2448	" 5— " " " "	87.24	2.81	2.47
2455	" 4— " pasteurized milk	83.81	3.85	3.33
246	" 5— " " " "	82.20	4.21	3.82
2475	" 5— " cooked milk	80.36	5.15	2.25
2487	" 6— " skimmed milk	82.00	8.50	Trace
2492	" 5— " " "	77.43	4.40	"
2497	" 7— " " "	81.47	5.01	"
2554	" 9— " whole raw milk	65.78	6.61	4.88
2559	" 8— " " " "	74.97	4.77	1.75
2566	" 9— " pasteurized milk	75.12	5.77	3.78
2571	" 8— " " "	79.93	4.05	1.36

The following tables, 8, 9 and 10, give the digestibility of the raw, pasteurized and cooked milk, together with the age of calf and the amount of milk fed, also other data. In these experiments the calf fed first on raw milk, then pasteurized, then on cooked milk. The calves are numbered in the tables. Thus, calf one was fed first on raw milk and the resulting data given in table 8 which is devoted to raw milk gives the necessary results and details. Then calf one was fed on pasteurized milk and the results and details are given in table 9 which is devoted to pasteurized milk. The calf was then fed on cooked milk but scoured so violently, as was the case in several other instances, that no results were obtained to give in table 10. This series was repeated with calf 2, and the results are given in tables 8 and 9, this one also scoured when fed on cooked milk. The series was again repeated with calf 1, which will be noted as being over a month old. Then calf 3 was used, and in this case the series was carried through the cooked milk as the calf did not scour as the others had done. In this way seven series were run through, three of which were fed cooked milk, from which the faeces were collected.

There was objection to this manner of carrying through the series always in the same order having the raw milk always come first. From a study of these tables it appears evident that the younger the calf the larger the per cent. of the food digested. It is a question because of this fact if the difference in age from the time of feeding raw to the time of feeding cooked milk might not have made some difference in the relative digestibility of raw and cooked milk. This fact had been noted in work done by other experimenters, but we considered that the difference would not be sufficient in the twelve days elapsing from the feeding of the raw milk to the feeding of the cooked milk to make any material difference in the results.

TABLE 8.

DIGESTIBILITY OF WHOLE RAW MILK.

Dura'ion of Preliminary Period, 3 Days. Digestion Period 3 Days.

Index No.		Fresh substance.	Dry substance.	Per cent. moisture.	Protein.	Fat.
	Calf 1-Age 15 days	grams.	g ams.		grams.	grams.
2313	Milk fed	24,390	2,926	88 00	770.72	780.48
2322	Total excreted	470	158	66.22	29.61	23.88
	Digested				741 11	757.60
	Per cent. digested				96.16	97.06
	Calf 2-Age 14 days.					
2345	Milk fed	24,390	3,171	87.00	748.11	902.43
2351	Total excreted	630	70	88.81	16.50	8.50
	Digested				731.61	893.83
	Per cent. digested				97.79	99.04
	Calf 1, Age 39 days					
2353	Milk fed	24,390	3,171	87.00	746.33	925.82
2359	Total excreted	2 490	944	62.08	221.61	95.83
	Digested				524.72	829.94
	*Per cent. digested				*70.30	*89.75
	Calf 3-Age 14 days.					
2382	Milk fed	24,390	3,293	86.50	782.91	924.38
2388	Total excreted	530	138	75.80	35.66	17.27
	Digested				747.25	1007.11
	Per cent. digested				95.44	98.31
	Calf 2-Age 53 days					
2391	Milk fed	24 390	3,293	86.50	778.16	975.60
2397	Total excreted	1 295	296	78.20	47.00	33.41
	Digested				726.16	942.19
	Per cent. digested				93.92	96.51
	Calf 4-Age 21 days.					
2434	Milk fed	18 714	2,536	86.50	658 73	823.41
244	Total excreted	1,455	359	75.82	30.11	22.22
	Digested				628.62	801.19
	Per cent. digested				95.68	97.31
	Calf 5-Age 14 days.					
2441	Milk fed	18 714	2,536	86.50	638.14	785.98
2448	Total excreted	2 325	296	87.24	65 33	57.42
	Digested				572.81	728.56
	Per cent. digested				89.76	92.69
	Average for 6 tests of raw whole milk, (Excluding the one marked*)				94.79	96 82
	Average for 7 tests of raw whole milk. *(including the one marked*)				91.29	95 81

TABLE 9.

DIGESTIBILITY OF WHOLE MILK PASTEURIZED 167 DEGREES F. FOR 10 MINUTES.

Duration of Preliminary Period, 3 Days. Digestion Period, 3 Days.

Index No.		Fresh substance.	Dry substance.	Per cent. moisture.	Protein	Fat
	Calf 1—Age, 21 days.	grams.	grams.		grams.	grams.
2384	Milk fed	24,390	2 926	88.00	760.96	804.87
2384	Total excreted	563	101	81.99	34.11	26.46
...	Digested	.....	.....	.....	726.85	778.41
...	Per cent digested	.....	.....	.....	95.51	96.71
	Calf 2—Age, 21 days.					
2383	Milk fed	24,390	3,171	87.00	756.09	876.04
2369	Total excreted	850	215	74.70	45.39	31.62
...	Digested	.....	.....	.....	710.70	844.42
...	Per cent. digested	.....	.....	.....	93.90	96.39
	Calf 1—Age, 46 days.					
2387	Milk fed	24,390	3,171	87.00	756.09	902.43
2387	Total excreted	1.580	219	86.13	38.55	12.64
...	Digested	.....	.....	.....	717.54	889.79
...	Per cent. digested	.....	.....	.....	94.90	98.59
	Calf 3—Age, 41 days.					
2406	Milk fed	24,390	3.293	86.50	819.50	975.60
2407	Total excreted	1,375	230	83.24	51 02	35.33
....	Digested	.....	.....	.....	768.48	940.27
....	Per cent. digested	.....	.....	.....	93.76	96.37
	Calf 2—Age, 71 days.					
2409	Milk fed	24,390	3,293	86.50	792.67	1,048.77
2415	Total excreted	2,935	644	78.04	82.47	58.70
....	Digested	.....	.....	.....	710 20	990.07
....	Per cent. digested	.....	.....	.....	89.59	94.40
	Calf 4—Age, 22 days.					
2449	Milk fed	18,714	2 586	86.50	636.27	785.98
2455	Total excreted	835	134	83.81	32.14	27.80
....	Digested	.....	.....	.....	604.13	758.18
....	Per cent. digested	.....	.....	.....	94.94	96.46
	Calf 5—Age, 21 days.					
2468	Milk fed	12,576	1,697	86.50	427.58	515.61
2467	Total excreted	1,185	211	82 20	49.88	45.29
....	Digested	.....	.....	.....	377.70	470.35
....	Per cent. digested	.....	.....	.....	88.33	91.02
	Average for 7 tests of Pasteurized milk at 167 F.	.....	.....	.....	92.99	94.27
	Average for raw milk	.....	.....	.....	94.79	96.82
	Dif. in favor raw milk	.....	.....	.....	1.80	2 55

TABLE 10.

DIGESTIBILITY OF WHOLE MILK COOKED.

Duration of Preliminary Period, 3 Days. Digestion Period, 3 Days.

Index No.		Fresh substance	Dry substance.	Per cent. moisture.	Protein.	Fat.
	Calf 2—Age, 41 days.	grams.	Grams.		Grams.	Grams.
2416	Milk fed	24,390	3,293	86.50	817.06	975.60
2425	Total excreted	1,040	232	77.60	48.98	13.20
....	Digested				768.08	962.40
....	Per cent. digested				94.00	98.64
	Calf 2—Age, 78 days.					
2427	Milk fed	18,714	2,536	86.50	649.37	767.27
2433	Total excreted	2,585	716	72.30	127.87	59 97
....	Digested				521.50	707.30
....	Per cent digested				80 30	92.18
	Calf 5—Age 44 days.					
2469	Milk fed	18,714	2,432	87.00	598.84	711.13
2475	Total excreted	1,455	285	80.36	74.93	32,73
....	Digested				323.91	678.40
....	Per cent. digested				87.48	95.39
	Average of 3 tests of cooked milk				87.26	95.40
	Average of raw milk				94.79	96.82
	Dif. in favor of raw milk				7.53	1.42
	Average for milk Pasteurized at 167° F. for 10 minutes				92.99	94.27
	Dif. in favor of Pasteurized over-cooked				5.73	1.13

FIRST SERIES.

In the first series of experiments which was carried through with calf 1 the animal appeared to be in perfect condition as regards its health, and though this was our first trial with the new apparatus everything worked very smoothly and nothing occurred worthy of note. The calf was also in normal condition when commencing on the preliminary period with pasteurized milk. When he was put in the crate to collect the faeces his bowels were rather loose, though he was not scouring and the faeces were collected and dried for analysis.

The calf's bowels had gotten in normal condition when we commenced to feed on cooked milk in the preliminary period and the calf was in apparent perfect condition in other respects. But at the end of the third day of the preliminary period the calf commenced to scour violently and continued to do so as long as the cooked milk was fed, which was about four days. It will be noted from the tables that in the raw milk 96.16 per cent. of the protein and 97.06 per cent. of the fat was digested, while with the pasteurized milk 95.51 per cent. of the protein and 96.71 per cent. of the fat was digested; a difference in the protein of .65 per cent., and in fat a difference of .35 per cent., both in favor of the raw milk. The cooked milk caused violent scouring, which is a sign usually of indigestibility. The calf gained one pound during the three days he was confined in the crate and fed on raw milk and gained three and one-half pounds in the same time while being fed on pasteurized milk.

SECOND SERIES.

In the second series which was carried through with calf No. 2 the calf entered on the preliminary period of feeding with raw milk in perfect condition and continued in good condition throughout the six days. When put in the crate, however, he worried considerably as though objecting to being confined. This may or may not have had some small effect on the per cent. digested or on the weight at the end of the period. He was in good condition when he commenced to feed on pasteurized milk in the preliminary period and while confined in the crate during the time was very quiet and he appeared to be perfectly normal in every way. For the three days of the preliminary period of feeding cooked milk he appeared in perfect condition, but on the morning he was placed in the crate he commenced to scour violently and had to be removed. The faeces during the time the calf was scouring was very thin and white, appearing much as though the milk had gone through the calf without being acted upon by the digestive juices. He was confined in the crate but one day and was then fed subnitrate of bismuth to check the scouring, this drug having proved very efficient temporarily in other cases of scouring. The cooked milk was continued during this time. The medicine had no effect and the scouring continued until the raw milk was substituted for cooked milk when it stopped in a very short time. The tables show that 97.79 per cent. of the protein and 99.04 per cent. of the fat in the raw milk, and 93.90 per cent. of the protein and 96.39 per cent. of the fat in the pasteurized milk was digested. This is 3.89 per cent. of protein and 2.65 per cent. of fat in favor of the raw milk. As we noted it appeared very much as though the cooked milk went through the calf without being acted on in the digestive tract. He gained nine pounds in three days while being fed raw milk and gained five pounds while being fed three days on pasteurized milk.

THIRD SERIES.

The third series was carried through with calf No. 1 which was 39 days of age at the beginning of the series. The calf was in good health at the beginning of the preliminary treatment with raw milk and continued so until the second day he was in the crate while being fed on raw milk, when his bowels were a little loose but not sufficiently so as to be called scouring or to make it inadvisable to collect the faeces for that day. In the feeding of the pasteurized milk the calf was in perfect condition and continued so throughout the six days. He was in good condition when he commenced on the preliminary period with cooked milk, but began to scour at the end of thirty-six hours after commencing and continued to scour three days, or until raw milk was substituted. After his bowels had got in normal condition we again started to feed cooked milk and he again commenced to scour in about forty-eight hours after the first feed. This time the feeding of the cooked milk was continued for four days after he commenced to scour, and efforts were made to check the scouring with drugs, but it continued until raw milk was substituted for the cooked when it stopped very shortly. The tables show that 70.30 per cent. of the protein and 89.75 per cent. of the fat fed in the raw milk and 94.90 per cent. of the protein and 98.59 per cent. of the fat in the pasteurized milk was digested which is 24.60 per cent. of protein in favor of the pasteurized milk. This is so at variance with the results obtained in every other case as to be abnormal and we have not included it in the averages. There was evidently some disturbing element which we can not account for, except we know that his bowels were rather loose on the second day and that he excreted an exceptionally large quantity of faeces apparently, however, without reason. The calf gained five pounds in three days while being fed on raw milk and two pounds in three days while receiving pasteurized milk.

FOURTH SERIES.

The fourth series was carried through with calf No. 3, which was fourteen days of age at the commencement. He was in normal condition while fed on raw milk and nothing worthy of note occurred during the six days. He was also in good condition when we commenced on the preliminary period feeding pasteurized milk, but when he was put in the crate he commenced to scour so badly that he was removed and fed on raw milk. Nothing more was done for three weeks when we again commenced on the preliminary period feeding pasteurized milk to the same calf. His bowels appeared to be a little loose the first day he was in the crate but the last two days he was constipated the faeces being hard. This calf was in good condition when we commenced on the preliminary period feeding cooked milk. He became badly constipated through the remaining four days. He was the first calf from which we had been enabled to collect the faeces while being fed on cooked milk. The tables show that 95.44 per cent. of the protein and 98.31 per cent. of the fat in the raw milk, 93.76 per

cent. of the protein and 96.37 per cent. of the fat in the pasteurized milk, and 94.00 per cent. of the protein and 98.64 per cent. of the fat in the cooked milk was digested. This is in favor of the raw milk, while more of the sterilized than pasteurized milk was digested. In three days while being fed raw milk the calf gained four pounds, he lost one pound on pasteurized milk and neither gained nor lost while being fed cooked milk.

FIFTH SERIES.

The fifth series was carried through with calf No. 2, which was about two months of age at the time. He was in good condition at the beginning of the feeding with raw milk and remained so to the end of the period. He was also in good condition when we commenced on the preliminary period with pasteurized milk, but at the end of the three days his bowels were so loose that we allowed him to go over another day before confining in the crate, when the trouble had become sufficiently corrected to warrant us collecting the faeces. His bowels remained a little loose, however, through the entire time and he excreted an exceptionally large amount of faeces which were very light colored. He was in good condition when we commenced feeding cooked milk, but his bowels were a little loose during the two days and he was constipated one day while he was confined in the crate. The faeces were collected for analysis. The tables show that 93.92 per cent. of the protein and 96.51 per cent. of the fat in the raw milk was digested; in the pasteurized milk 89.59 per cent. of the protein and 94.40 per cent. of the fat was digested, while in the cooked milk 80.30 per cent. of the protein and 92.18 per cent. of the fat was digested. This leaves a comparatively wide margin in favor of the raw milk. The fact that the calf's bowels were loose may have accounted for the relatively small per cent. digested in the cooked milk. He gained one pound on raw milk, gained two pounds on pasteurized milk and lost one pound while being fed on cooked milk.

SIXTH SERIES.

The sixth series was carried through with calf four which was twenty-one days of age at the commencement. He was in perfect health during the entire time he received raw milk and was also in good health apparently during the entire period he received pasteurized milk. He was in good health when we commenced to feed him scalded milk but the first day he was in the crate he scoured so badly we were forced to remove him. The tables show that this calf digested 95.68 per cent. of the protein and 97.31 per cent. of the fat fed in the raw milk, and 94.94 per cent. of the protein and 96. 46 per cent. of the fat fed in the pasteurized milk leaving a small margin in favor of the raw milk. During the three days he was fed on raw milk he lost one pound in weight and during the same period of time he was fed on pasteurized milk he gained two pounds.

SEVENTH SERIES.

The seventh series was carried through with calf 5 which was 14 days old. He was a little loose at the commencement of the preliminary period with raw milk and remained in that condition through the six days he was fed, but was not scouring so badly as to make the collection of the faeces inadvisable. The faeces were quite light colored during this time. His bowels continued loose during the time he was fed pasteurized milk in the preliminary period but this was corrected when he was put into the crate though the faeces collected during this time were light colored. The last day he was in the crate he scoured so badly that the faeces were not collected and we allowed the average of the two days the faeces were collected to be used as a basis for calculating the results. He was in good condition when we commenced on the preliminary period feeding cooked milk. During the time he was confined in the crate the consistency of the collected faeces was very unnatural, part of each passage being very hard and dry and part very thin as though the calf was scouring badly. He digested 89.76 per cent. of the protein and 92.69 per cent. of fat in the raw milk; 88.33 per cent. of the protein and 91.02 per cent. of the fat in the pasteurized, while he digested 87.48 per cent. of the protein and 95.39 per cent. of the fat in the cooked milk, which leaves a small margin in favor of the raw milk. His weight remained stationary for the three days he was confined in the crate while being fed raw milk, he gained three pounds in the same time while being fed pasteurized milk, and gained four pounds while being fed cooked milk.

CONSIDERATION OF ALL AVERAGES IN ALL SERIES.

In reviewing the average results of the seven series we find the digestive coefficients are, with one exception, slightly in favor of raw whole milk. Considering the general character of the milk, its high digestibility and the accuracy of chemical methods used in its analysis, the small differences in milk differently treated are sufficient to warrant drawing conclusions; especially as the parallel results in the same series agreed so closely. These small differences, of course, in ordinary digestion experiments with complex substances, like fodders, would almost simply be within the limits of error of such work, and hence, indicate but little.

In the one trial where the results favored the pasteurized milk the variation in the digestibility of the raw milk from what had been digested in the other six trials was so great as to make us almost positive that some disturbing factor was present which would justify us in excluding this from the average results and from all consideration in this connection. Of the raw milk fed in the six trials the average shows that 94.70 per cent. of the protein and 96.82 per cent. of the fat was digested. Of the pasteurized milk the average of the seven trials shows that 92.99 per cent. of the protein and 94.27 per cent. of the fat was digested. With the three trials of cooked milk in which we were able to collect the faeces the average shows that 87.26 per

cent. of the protein and 95.40 per cent. of the fat was digested. Comparing raw milk and pasteurized milk we see that 1.80 per cent. more protein and 2.55 per cent. more fat was digested in the raw than in the pasteurized. This is a small difference, but the constant variation in favor of the raw milk in the six trials considered makes the difference as far as practical with our conditions conclusive though small. In comparing the raw milk with the cooked milk we find 7.53 per cent. more protein and 1.42 per cent. more fat digested in the raw than in the cooked. This is quite a wide variation in the protein and in view of this the comparatively small variation in the fat is rather striking. The higher heat seems to have a much less influence on the digestibility of the fat than on the protein. This is rather to be expected, however, as we would suppose that heat would have much more physical effect on the casein of the milk than it would on the fat. In comparing the pasteurized milk with the cooked milk we find that 5.73 per cent. more of the protein in the pasteurized milk was digested than in the cooked, while 1.13 per cent. more fat in the cooked milk was digested than in the pasteurized. Here again the fact that heat does not have as great an effect on the fat as on the protein is noted. In considering the gain in weights we find that the average gain for the three days the calves were confined in the crates where raw milk was fed was 2.7 pounds, where pasteurized milk was fed it was 1.6 pounds for the same time, and with cooked milk the gain was one pound. This variation was not great, but it must be remembered that it covered a period of only three days. It is well to notice that the average in all instances showed some gain, though a few individual animals lost slightly.

In the experiments the results of feeding cooked milk to the calves was unexpected and widely different from the established theory in regard to the action of such milk on the animal stomach. Cooked milk is usually supposed to cause constipation, and it is often advocated as a cure for scours in calves. Instead it seemed to have the opposite effect when fed to the calves used in this experiment. As has been noted, out of the seven trials in feeding cooked milk, four cases of severe scouring resulted. So pronounced and unusual were the results, that we determined to make repeated trials, and so in the early part of our work cooked milk was fed to six different calves and resulted in scouring all of them. We had considerable trouble with scours at about this time among the calves we were not using in the experiments, but in only one instance did the calf receiving raw whole milk in the experiment scour so badly that we could not collect the faeces, and there was also a similar instance with the pasteurized milk, while in the cooked milk the calves repeatedly scoured, even when drugs were given to prevent it. At another period in the experiments when the calves, as a whole, were not scouring we tried feeding cooked milk again, and it was at this time that we succeeded in getting three of them to go through the six days of experiment without scouring. In two other trials not recorded the calves did not scour, and in three trials at about the same time they did scour. It seemed as though

there was a tendency among the calves to scour and the trouble was aggravated when the calf was fed cooked milk. Where there was not such a marked tendency to scour the faeces would be hard and dry when cooked milk was fed.

A comparison of the results obtained with the calves and those obtained in feeding milk to dogs and children may be interesting. In the experiments recorded in tables 1 and 2 where the milk was fed to a dog at different periods of its growth, about 87 per cent. nitrogen and 95 per cent. of the fat of raw milk was digested. In cooked milk fed to dogs 84 per cent. of the nitrogen and 95 per cent. of the fat was digested. In the work of Koplik with infants 96.6 per cent. of the protein was digested in the raw milk, 95.4 per cent. of the protein in the pasteurized milk was digested and in the cooked milk 95.5 per cent. of the protein was digested. In our work with the calves 94.8 per cent. of the protein and 96.8 per cent. of the fat in the raw milk was digested; in the pasteurized milk 93 per cent. of the protein and 94.3 per cent. of the fat was digested; and in the cooked milk 87.26 per cent. of the protein and 95.4 per cent. of the fat was digested. Some unexpected peculiarities are shown in these figures, not the least of which is the fact that the infants fed on cow's milk seemed to be able to digest a far greater per cent. relatively than the dog; and it must be remembered that these infants, one especially, were in the hospital because of sickness while the dog was in perfect health. This, by many, will be regarded as being strange as dogs are supposed to be provided with very strong digestive organs and would be supposed to be able to make use of a relatively large portion of the food eaten. Another strange fact is, that the infants digested a greater per cent. of the protein fed than the calves when the cow's milk is a foreign food for the infant and is the natural food of the calf. This also is emphasized by the fact that the calves were in perfect health and one of the infants was not. The difference in the per cent. digested was not great, but the wonder is that it was not largely in favor of the calves. The comparison of the per cents of protein and fat digested by infants, calves and dogs can be seen in table 11.

TABLE 11.

Comparative Per Cent. of Protein and Fat of Raw Milk Digested when Fed to Infants, Calves and Dogs.

Subject used.	Per cent. protein. digested.	Per cent. fat. digested.
Infants,	96.6	——
Calves,	93.7	96.46
Dogs,	87.2	95.00

PASTEURIZING AT 140 DEGREES F.

As was noted before, Russell and Farrington of the Wisconsin Experiment Station found that milk could be heated to 140 degrees F. without the perceptible physical effect on certain of its properties

that was noticed when a higher heat for a shorter period was employed. It was also found that this gave a very efficient pasteurization. We thought that this being the case digestion experiments with milk pasteurized at this temperature were worthy of trial, as it was reasoned that what might have a different noticeable physical effect on the milk would be very likely to effect its digestibility. In these experiments, as in the others, the milk from the two cows was used for the feeding, the same quantity was fed and the pasteurizing was done with a shot gun can which was immersed in a tub of hot water, the temperature being maintained at 140 degrees F. for thirty minutes when the milk was rapidly cooled. As will be noted the calves were a little older in these experiments and unfortunately the series was repeated but twice Before taking this share of the work we had waited until the faeces from the first experiments had become dried sufficiently for analysis, and during the time our supply of calves had become almost exhausted. The results obtained, however, are comparative with the results obtained with the raw milk fed the same calves, and while the per cents digested in both are somewhat below that obtained in the previous experiments, it can undoubtedly be accounted for on the grounds that the calves were older, which was mentioned before as seemingly to have some effect on the per cent. of the milk digested. The results can be seen in the following tables.

TABLE 12.

DIGESTIBILITY OF WHOLE MILK

Duration of Preliminary Period, 3 Days. Digestive Period, 3 Days.

Index No.		Fresh substance.	Dry substance.	Per cent. moisture.	Protein.	Fat.
	Calf 9—Age 41 days.	grams.	grams.		grams.	grams.
2540	Milk fed	18,714	2,536	86.50	641.89	748.56
2543	Total excreted	700	239	65.78	46.27	34.16
	Digested				595 62	714.40
	Per cent. digested				92.79	95.43
	Calf 8—Age 46 days.					
2455	Milk fed	18,714	2,536	86.50	617.56	767.27
2459	Total excreted	970	243	74.97	46.26	16.97
	Digested				571.30	750.30
	Per cent, digested				92.50	97.78
	Average, two tests				92.64	96.10

TABLE 13.

DIGESTIBILITY OF WHOLE MILK PASTEURIZED 140 DEGREES F.—30 MINUTES.

Duration of Preliminary Period, 3 Days. Digestive Period, 3 Days

Index No.		Fresh substance.	Dry substance.	Per cent. moisture.	Protein.	Fat.
	Calf 9-Age 47 days	grams.	grams.		grams.	grams.
2560	Milk fed	18,714	2,586	86.50	589.59	748.56
2566	Total excreted	810	261	75.12	46.73	30.61
	Digested				542.76	717.95
	Per cent. digested				92.07	95.50
	Calf 8-Age 54 days.					
2568	Milk fed	18,714	2,536	86.50	625.04	748.50
2571	Total excreted	1,240	249	79.93	50.22	16.86
	Digested				574.82	731.70
	Per cent. digested				91.96	97.73
	Average 2 times, pasteurized 140 F for thirty minutes				92.01	96.61
	Average for raw milk				92.64	96.10
	Protein difference in favor of raw milk				.63	—.51

FIRST SERIES.

The first series was carried through with calf 9. The calf was in perfect health all through the feeding with raw milk, and as far as could be seen everything was normal. He was also in good shape when he started on the preliminary period with pasteurized milk but the faeces collected were hard and dry. As can be seen by the table 92.29 per cent. of the protein and 95.40 per cent. of the fat in the pasteurized milk was digested. This is but .29 per cent. in favor of the raw milk in the case of the protein and is 2.36 per cent. in favor of the pasteurized milk in case of the fat.

SECOND SERIES.

The second series was carried through with calf 8, which was 46 days old at the commencement of the trial. This calf was in perfect health during the trials, both with the raw and with the pasteurized milk, and aside from the manure being a little hard in both cases every-

thing was apparently normal. The tables show that 92.50 per cent. of the protein and 97.75 per cent. of the fat in the raw milk was digested; and 91.96 per cent. of the protein and 92.23 per cent. of the fat in the pasteurized milk was digested. This is .54 per cent, of protein in favor of the raw milk, while the per cents of fat were about even.

The average variation in these two trials was .63 per cent. of the protein in favor of the raw milk and .51 per cent. of the fat in favor of the pasteurized milk. Between the milk pasteurized at 167 degrees F. for ten minutes and the raw milk fed in the same series there was a difference of 1.80 per cent. of the protein in favor of the raw milk. With milk pasteurized at 140 degrees F. for thirty minutes there was a difference of but .63 per cent. of protein. With the fat there was a difference of 2.55 per cent. in favor of the raw milk in the first case and a difference of .51 per cent. in favor of the pasteurized milk, with milk pasteurized at 140 degrees F. for thirty minutes.

These differences found in the digestibility are, of course, not relatively great, but smallest difference is found in the milk pasteurized at 140 degrees F. for thirty minutes, and judging from these trials it is reasonable to suppose that if pasteurizing milk for infant use, is a positive injury, and is resorted to simply as the less of two evils, milk pasteurized at the lower temperature would be the least injurious and consequently to be preferred. As has been said before, there are certain physical changes noticeable in milk pasteurized at 150 degrees F. and above, which are not found in milk pasteurized at 140 degrees F. Milk pasteurized at 150 degrees F. and above always has something of a cooked flavor, and this temperature also destroys the body of cream, making it thinner and less viscous. This has always been considered as undesirable, and as pasteurizing at 140 degrees F. does not have this effect it, for this reason, would be a more favorable temperature to use. As was admitted, the age of the calves, and the fact that the experiment was carried through but twice is unfortunate, but the results from the two experiments were practically the same and will be accepted by many as being conclusive for the conditions.

While the pasteurizing was being done bacteriological tests of the milk were made in a number of instances to determine the efficiency of the work done.

The two following tables, 13 and 14, will show this to good advantage. One sample was taken just before heating the milk and another was taken as soon as the milk had been heated for the necessary time, and before it was cooled:

TABLE 14.

MILK PASTEURIZED AT 167 DEGREES F. FOR TEN MINUTES.

	No. germs per cc before pasteurizing.	No. germs per cc after pasteurizing.	Per cent. of germs killed.
1st trial	12,740	270	98.
2nd trial	13,520	210	98.5
3rd trial	8,320	120	98.6
4th trial	19,890	180	99.1
5th trial	37,440	90	99.8
Average			98.8

TABLE 15.

MILK PASTEURIZED AT 140 DEGREES F. FOR THIRTY MINUTES.

	No. germs per cc before pasteurizing.	No. germs per cc after pasteurizing.	Per cent. of germs killed.
1st trial	70,980	1,300	98.3
2nd trial	1,662,000	2,860	99.8
3rd trial	130,130	1,740	98.7
4th trial	244,176	544	99.8
5th trial	413,712	1,590	99.6
6th trial	321,776	2,020	99.4
Average			99.2

Five determinations were made with the milk pasteurized at 167 degrees F., and six trials with the milk pasteurized at 140 degrees F., and the tables show that while both were reasonably efficient, the pasteurizing at 140 F. for thirty minutes was more so than at 167 degrees F. for ten minutes. This milk, before pasteurizing, was allowed to stand from about 5.30 in the morning until 7.30 without cooling, when the first sample for analysis was taken. This accounts for the comparatively large number of germs in the milk before heating. The pasteurizing at 167 degrees F. was done during the cold weather of winter, and the pasteurizing at 140 degrees F. was done in the spring when the weather was warmer, which accounts for the greater number of germs in the unpasteurized milk at the latter period.

DIGESTIBILITY OF SKIMMILK.

While we are working on the digestibility of milk there were several problems which impressed us as being worthy of investigating, and one of these was the digestibility of skimmilk. Enormous quantities of skimmilk are taken from the creameries of the country every year and fed with good results to hogs and young calves. Among families where only one cow is kept or where there is a tendency to be economical in saving the cream for table use or butter making, the skimmilk is used for drinking, and many small children receive a large share of their nourishment in this way. That skimmilk is nourishing has never been denied except in a few instances where ignorance has led to the claim that separator skimmilk was so poor as to be unfit for use. It is palatable, to many even more palatable than the whole milk, and its wholesale use makes it interesting to know if the removal of the fat from the other constituents causes the latter, especially the protein to be any harder to digest than they are when the whole milk is consumed. To determine this point as far as it could be done with calves we determined to make three trials along practically the same lines as we had done in testing the digestibility of raw, pasteurized and cooked milk. The milk from the two cows which supplied the milk for the previous experiments was separated alone, the quantity of fat left in the skimmilk being about .1 per cent. The milk was subjected to chemical analysis, the same quantity by weight was fed, and everything was carried through in practically the same way that it had been before, with the exception that the small quantity of fat left in the milk was not taken into consideration, no analyses being made for fat, either in milk or faeces. We fed no whole raw milk to these calves, believing that the average results obtained in feeding the raw milk in the other experiments would do for comparison with the results obtained in the skimmilk.

TABLE 16.

DIGESTIBILITY OF SKIMMILK.

Duration of Preliminary Period, 3 Days. Digestion Period, 3 Days.

Index No.		Fresh substance.	Dry substance.	Per cent. moisture.	Protein.	Fat.
	Calf 6—Age 14 days.	grams.	grams.		grams.	grams.
2481	Milk fed	18,714	1,777	90.50	645.63	.....
2487	Total excreted	875	157	82.00	30 63	.....
	Digested	.....	.....	.....	615.00	.....
	Per cent. digested	.....	.....	.....	95.24	.....
	Calf 5—Age 51 days.					
2488	Milk fed	12,576	1,204	90.50	427.58	.....
2492	Total excreted	525	118	77.40	24.20	.....
	Digested	.....	.....	.....	403.38	.....
	Per cent. digested	.....	.....	.....	94.34	.....
	Calf 7—Age 15 days.					
2494	Milk fed	18,714	1,777	99 50	645.53	.....
2497	Total excreted	775	14,360	81 47	37.82	.....
	Digested	.....	.....	.....	607.71	.....
	Per cent. digested	.....	.....	.....	94.14	.....
	Average for 3 trials with skimmilk, raw	.....	.....	.....	94.57	.....
	Average for raw milk, whole	.....	.....	.....	94.79	.....
	Difference in favor of raw milk, whole	.....	.....	.....	.22	.....

The first trial was made with calf 6, which was fourteen days old at the time. The calf was in good health in every way apparently, but when he was put in the crate he worried very much and continued to do the same until he was removed at the end of the three days. He lost six pounds in the three days he was kept in the crate and it was likely that the worrying was largely the cause of it. The table shows that it digested 95.24 per cent. of the protein fed in the milk.

The second trial was carried through with calf 5 which was fifty-one days old at the time. He was in good health at the beginning of the preliminary period but when we commenced to collect the faeces the first day they were thin, though not sufficiently so to say that the calf was scouring. The second day the calf was still loose and the third day he was very loose. The table shows the calf to have digested

94.34 per cent of the protein in the milk fed. He lost one pound in the three days he was confined in the crate.

The third trial was carried through with calf 7, which was 15 days old at the commencement of the preliminary period. He was in perfect health during the entire six days and everything went through without incident. The table shows that he digested 94.14 per cent. of the protein in the milk fed. He lost two pounds in weight during the two days he was confined in the crate.

The average per cent. of protein digested in these trials was 94.57. The average of the raw whole milk fed in the seven trials given in table 8 was 94.79 per cent. This is a very small fraction in favor of the raw milk though not sufficient to be considered and well within the limits of error. The most noticeable feature in these trials was the loss in weight in every calf used while confined in the crate. This was to be expected, however, when feeding them milk which had practically almost all the fat removed, in the same quantities that the raw whole milk had been fed in previous experiments. Judging from these trials removing the fat does not decrease the digestibility of the protein of the milk.

The following table 16, puts in tabulated form the weight at the beginning and at the end of each experiment with the resulting gain or loss. Each calf was weighed just before being put into the crate and again at the end of the three days' period in the crate. The almost universal gains, show conclusively, that the calves used were in a healthy condition and were not materially affected by being forced to remain in an upright position for three days. Where there was a noticeable gain in weight in the three days it is reasonable to suppose that the calf was in perfect health.

TABLE 17.

WEIGHTS OF CALVES AT THE BEGINNING AND END OF DIGESTION PERIODS.

Kind of Milk Fed.	Calf. Trial.	Weight at beginning, lbs.	Weight at end of 3 days, lbs.	Gain in 3 days, lbs.
Raw Whole (2313)	Calf 1-1st trial.	94	95	1
" " (2345)	" 2-1st "	78	87	9
" " (2353)	" 1-2nd "	122	127	5
" " (2382)	" 3-1st "	87	91	4
" " (2391)	" 2-2nd "	116	117	1
" " (2434)	" 4-1st "	88	87	—1
" " (2441)	" 5-1st "	79	79	——
Average gain in seven trials				2 71
Pasteurized 167 for 10 min. (2324)	Calf 1-1st trial.	95.5	99	3.5
" " " " " (2363)	" 2-1st "	88	93	5
" " " " " (2372)	" 1-2nd "	128	130	2
" " " " " (2400)	" 3-1st "	120	119	—1
" " " " " (2409)	" 2-2nd "	137	134	—3
" " " " " (2449)	" 4-1st "	94	96	2
" " " " " (2462)	" 5-1st "	79	82	3
Average gain, seven times				1.64
Cooked (2416)	Calf 3-1st trial.	118	118	0
" (2427)	" 3-1st "	142	141	—1
" (2469)	" 5-1st "	94	98	4
Average gain, three times				1
Skimmed (2481)	Calf 6-1st trial.	127	121	—6
" (2488)	" 5-1st "	96	95	—1
" (2494)	" 7-1st "	100	98	—2
Average loss, three times				3
Whole Past. 140 for 30 min. (2560)	Calf 9-1st trial.	119	117	—2
" " " " " " (2568)	" 8-1st "	127	131	4
Average gain, two times				1

The following table gives a summary of the average digestibility of the protein and fat of the milk used in each experiment, and brings the results together so as to make easy their comparison.

TABLE 18.

DIGESTION COEFFICIENTS OF MILK DIFFERENTLY TREATED.

Kind of milk.	Per cent. digested.	
	Protein.	Fat.
Raw whole milk	94.79	96.82
Whole milk, pasteurized 167 degrees for 10 minutes	92.99	94.27
Whole milk, cooked	87.26	95.40
Skimmed milk	94.57	.....
Whole milk, raw	92.64	96.10
Whole milk, pasteurized 140 degrees for 30 minutes	92.01	96.61

Calves over six weeks old.

The average results obtained in our work give an interesting study covering the actual digestibility of milk. It is almost always stated by authorities on such subjects that milk is entirely digestible. Theoretically, perhaps, it is as it contains none of the material which is recognized as the indigestible part of grains and fodders. In practical work, however, there is found to be a relatively large portion indigestible. In the work recorded in this bulletin the digestibility of the milk fed would average about 93 per cent. with the protein and a little higher with the fat, some of the per cents. being much lower than this in individual cases. It is likely that had a smaller portion of milk been fed a larger per cent. would have been digested, and by reducing the amount to the minimum required to sustain life it is possible that practically all fed would have been utilized in the system. But where sufficient milk is fed to insure substantial growth, nearly one-tenth of the dry substance is undigested.

CONCLUSIONS.

1. Raw milk is more easily digested when fed to calves than either pasteurized or cooked milk.

2. Contrary to theory, cooked milk when fed to the calves used in these experiments caused violent scouring in the majority of trials.

3. A majority of physicians in charge of children's hospitals corresponded with, favored the use of raw milk for infants when the milk is known to be in perfect condition, but favored pasteurized milk under ordinary conditions.

4. With one exception all the physicians corresponded with discourage the use of cooked or sterilized milk for infant feeding.

5. Skimmilk was found to be as digestible as whole raw milk.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 78. DECEMBER 1901.

THE DEHORNING OF STOCK.

By C. F. Doane.

INTRODUCTION.

In presenting a bulletin on this subject at this time it is not intended to give any new or original facts, but merely to place on record the observations that have been made at this station in connection with dehorning, and also to supply the information which is frequently requested concerning the methods for dehorning, especially directions for the use of chemicals on calves to prevent the growth of horns.

HISTORY.

The first dehorning in this country, on a large scale, of which there is any record, was done by an Illinois farmer, who was engaged in the production of beef cattle. Previous to this there had been sufficient experience in the necessary surgical work of veterinarians to know that the horns could be removed from a mature animal without any particular danger to its life. At different places in Europe dehorning had been practiced for a number of years and it is very likely that it was the reports from these places that first led to the practice in this country. It was not long after the first dehorning in Illinois that its advantages were realized and the practice spread rapidly. The beef herds were the first dehorned, and then the dairy herds, as it was seen that, at times, horns were a disadvantage among milking stock. The idea spread east and west, to some extent, and now, in any part of the country, herds of dehorned cattle are a familiar sight; while, in the middle West, among the large beef raisers and even among the dairymen, the great majority of the herds are dehorned. Especially is this true among the working herds of cattle. In show herds the consideration of the natural appearance of the animal retain the horns.

ADVANTAGES AND DISADVANTAGES.

The horns of cattle were evidently given to them as a means of defense. With their domestication the need of horns has entirely disappeared, and, in fact, the horns in most cases are a positive injury to the herd and are certainly a menace to the attendants as well as making the herd less economical in a number of ways. In the rais-

ing of all kinds of stock, the well being of the individuals of the herd is always the first consideration, but in a herd where all the cattle have horns it is a rather common occurrence for one of them to be injured by hooking from another animal. It may be nothing more than a gash, but it is painful to the animal receiving it, injures the hide, and in some cases, may prevent growth for a time. Sometimes a valuable cow or steer is killed, and where horses and cattle are allowed to run together, as they often are, it is very common for a horse to be killed or severely injured by being hooked. In the feed lot there is a material economy of space by having cattle without horns. Less shed room, and not so much trough or manger space, is required. Especially is this true where a few in the herd are unusually vicious as is often the case, and where there are a few timid animals, twice as much space is required to insure that the timid ones shall receive their fair share of feed and shelter. Where all the members of the herd are without horns fattening steers will stand as closely around a feed box as they can be packed, and the shed room required is determined by the actual space needed by each animal for its comfort. The timid ones in the herd soon learn that the others can cause them no pain, and the bosses find that it requires too much of an effort to keep the others on the move; and the result is a more peaceful herd which fattens more evenly with considerably less space.

With dairy cows, which spend a large share of their time in stables, the greatest objection to horns are from the injury which may be suffered by attendants. In caring for milking cows it is necessary to come very close to the heads of the animals, and in tossing the head around either in fright or in fighting flies, there is danger of the attendant being struck in the face and painfully injured. The cows often injure each other too, and taking it all in all make a quieter herd if they are without horns.

The necessity of having the horns removed from bulls, especially if they are allowed to run loose a part of the time, is being continually called to mind. In very few instances have the numerous deaths, caused by vicious bulls, been caused by one without horns. Bulls, as they advance in age, are very prone to become ugly and hard to manage; but if their horns are removed, they realize that they are deprived of their natural weapons and are much less likely to attempt to injure anyone. If they do attempt it, while they may be able to severely bruise a grown man, they are very unlikely to kill him outright.

There are three arguments which have been urged against dehorning. It is claimed that the dehorning of mature animals causes such intense suffering that it should never be practiced. Again it is claimed by some very prominent dairymen that, as the dairy cow possesses a very highly organized nervous system, the removal of the horns may in some way permanently injure her dairy qualities; and still others would allow the horns to remain as their removal injures the beauty of the animal to a certain extent. This latter argument may and does interest men who are raising highly bred stock

for selling purposes, but to the majority of dairymen the question of the appearance of the cow is very remotely a secondary one. They are interested almost solely in the economic aspects of the case. On the other hand many breeders have expressed a preference for polled cattle and to meet this demand there have been attempts to establish polled varieties of some of the well known breeds. This is accomplished by selecting sports without horns which are occasionally dropped in all breeds, or by crossing the breed with one of the well known polled breeds. The horns are very easily bred off the animal. The polled Durhams are becoming to be quite an important breed, and there is also a few herds of polled Jerseys. It is possible, that in time, these varieties may almost entirely supplant the original breeds.

Dehorning may possibly, as suggested, injure the dairy qualities of the cows, but the probability of its doing so is rather remote and the great majority of the smaller dairymen are more interested in the immediate effects of the operation. That the removing of the horns from the mature animal causes great suffering for the period of the operation cannot be doubted, but it is also true that a herd with horns cause each other, and especially the weaker ones, more suffering in the course of time than the removal of the horns possibly could cause. Just how great and prolonged is the pain from sawing or clipping the horns is difficult to ascertain with any degree of exactness. In a number of instances, humane societies have instituted proceedings against owners of herds for having them dehorned. In this country these suits, as far as we have been able to find out, have always resulted in the acquittal of the accused party. One man in Canada was convicted and fined, but the affair led to the appointment of a commission which investigated the matter thoroughly, and reported that dehorning was justifiable. This put an end to all such prosecutions in Canada. It is unlikely that dehorning causes more pain than the castration of calves, pigs and colts, which is for a purely economic reason and is never questioned as being inhuman.

With our knowledge of fattening cattle, and especially of milking cows, we would consider that the effect on the gain in weight of the steers, or in the milk yield of the cows would be some indication of the immediate effect of dehorning. The removal of the horns is certainly more or less a nervous shock to the animal. If this shock is great enough, it would check the growth of the steer. Those who are familiar with the better class of dairy cows know that they have a very highly organized nervous system, and any shock to the nerves would show immediately, both in the quantity and quality of milk produced. Any excitement in a herd has this same effect, so that any material change in the quantity and quality of the milk at the time of dehorning could be considered to be due either to the dehorning or the attendant excitement.

EFFECTS OF DEHORNING RECORDED AT SOME EXPERIMENT STATIONS.

At a number of the experiment stations exact records of the daily milk yield before and after dehorning have been kept. In a few instances the per cent of butter fat has also been noted at each milking for a few days before and after dehorning, and from these we can make a pretty fair estimate of the effect of dehorning on the dairy cow.

At the Wisconsin Experiment Station, a record of ten cows was kept for the four milkings before dehorning, and four milkings immediately following dehorning. The ten gave 289.3 pounds in the four milkings before, and 243.6 pounds of milk in the four milkings after dehorning—a loss of 45.7 pounds or 16 per cent. Each cow was tested two milkings before dehorning and four milkings after dehorning. In every case but one the milk tested much lower the milking immediately after dehorning than it had tested the two milkings before dehorning. But the test gradually increased until it was much higher than it had been in the milkings previous to dehorning, and the actual amount of butter fat produced by the cows was as much or more than it would have been had the cows not been dehorned. At another time at the same station, twelve cows were dehorned with a loss of 5 per cent in the total yield of milk in six days after dehorning, and a gain of 4 per cent in the total amount of fat produced in the same time. A record of the weights of the cows before and after showed practically no loss due to the operation.

At the Minnesota Station nine cows produced 7 per cent less milk in three milkings following dehorning than they had given in the three previous milkings, and produced 3 per cent less total butter fat in the same period. Six cows which had been kept where they could see the excitement and smell the blood, lost 3 per cent. in their milk yield and 1 per cent in their total butter fat in the same time, showing that the slight loss of the dehorned cows was due partially to excitement. A weak feature in this record was that three milkings were selected, making two nights' and one morning's milking in one period, and two mornings' and one night's milking in the other period. Cows seldom give the same at morning and night, and the test nearly always varies at these two milkings.

At the Georgia Station, nine cows made an actual gain in milk yield the day following dehorning.

At the Tennessee Station, nineteen cows were dehorned, and in ten days they lost only 34.2 lbs. of milk from a total previous ten days' yield of 2,784.3 pounds.

The New York Station, at Cornell, found that five cows lost an average of one pound a day for four days following dehorning. Seven cows not dehorned lost an average of one-half pound a day in the same time. One of the dehorned cows lost an average of 4 lbs. per day in the recorded time.

At the North Dakota Station 14 cows were dehorned. Most of them fell off in their milk slightly, but gained in per cent of butter fat, and at the fourth milking all were back to their normal flow. The

14 cows made about 1 lb. less butter in the two days following dehorning than they had made in the two previous days.

From these reports it appears that there is a very small per cent of loss in the total amount of milk produced, and very little if any loss in the total fat produced in the first few milkings following dehorning. In the majority of recorded trials the cows came back to their natural flow of milk in less than a week, often in two days. Judging from this there is no amount of pain suffered by the cow, and practically no loss in product resulting from the operation. It must be emphasized that as far as our knowledge of the dairy cow goes at the present day, we would be practically sure that any protracted pain, or any great physical shock, would lead to a material reduction in the amount of milk produced. It seems that the excitement of struggling with the cows operated on, and handling them in a manner to which they are not accustomed, is almost as operative in reducing the milk flow as the dehorning itself.

EFFECTS OF DEHORNING WITH MARYLAND STATION HERD.

Our own experience in dehorning was obtained at two different times. The cows bought by the Station came with their horns on, and as it was thought advisable to remove the horns, all of the cows owned by the Station at that time were dehorned. They were thirteen in number and had been in milk for varying periods of time. The effect in the milk yield can be seen in the following table:

TABLE I.

Cows Dehorned April, 1897.

Cow No.	Gave in 4 days before dehorning.	Gave in 4 days after dehorning.	Loss in lbs.	Loss per cent.	Calved.
1	30.5	29.0	1.5	4.9	Feb. 10, 1896
2	48.5	51.5	*3.0	*6.2	Feb. 29, 1896
4	69.0	69.5	* .5	* .8	Sept. 19, 1896
10	57.9	56.7	1.2	2.0	Feb. 19, 1896
11	78.9	77.0	1.9	2.0	Jan. 20, 1897
12	81.3	74.3	7.0	8.3	Jan. 21, 1897
13	64.3	58.9	5.4	8.4	Nov. 21, 1896
14	74.5	72.9	1.6	2.0	Aug. 23, 1896
16	66.8	63.0	3.8	5.7	Sept. 24, 1896
17	71.2	66.9	4.3	6.0	Nov. 17, 1896
18	53.7	52.4	1.3	2.0	Aug. 20, 1896
19	67.7	61.9	5.8	8.5	Nov. 12, 1896
20	35.0	29.0	6.0	17.0	Aug. 18, 1896
Total.	790.3	763.0	36.3		
Av'r'ge.	61.5	58.7	2.8	4.5	

*Made an actual gain.

It will be noticed that most of these cows were very far advanced in their periods of lactation, and there must have been a steady, though slow, natural decline in the amount of milk produced. This, of course, does not account for the relatively sudden shrinkage shown, though it would explain a part of it. There was some falling off in the quantity produced, due to the dehorning, but it would hardly be called great enough to deter anyone from dehorning a herd because of the actual financial loss it would cause.

A recent trial at dehorning was in 1901, when a number of the heifers from the original stock had reached maturity and some more cows had been purchased. A few had been dehorned at different times prior to this, but it was in such small numbers at any single time that no special record was kept of their milk yields before and after. The following table gives the results with the nine cows dehorned:

TABLE II.

Cows Dehorned May, 1901.

Cow No.	Gave in 4 days before dehorning.	Gave in 4 days after dehorning.	Loss in lbs.	Loss per cent.	Calved.
34	59.3	39.9	19.4	32.0	Apr. 14, 1901
35	95.1	70.2	24.9	26.0	Sept. 16, 1900
37	72.7	42.6	30.1	42.0	Oct. 15, 1900
38	42.9	21.1	21.8	50.0	Oct. 26, 1900
39	41.8	27.9	12.9	31.0	May 2, 1900
57	85.6	75.0	10.6	12.0	Mar. 1, 1901
58	92.7	79.9	12.8	14.0	Feb. 1, 1901
59	99.8	55.2	44.6	44.0	Mar. 15, 1901
60	83.6	61.2	22.8	26.0	Mar. 1, 1901
Total,	672.5	473.0	199.5		
Av'r'ge,	74.7	52.5	22.2	30.8	

The records obtained in Table II are chiefly interesting for the heavy falling off in the quantity of milk produced, which shrinkage averaged 30.8 per cent of the whole amount. This is much heavier than reported in the records from any of the other stations, and is certainly much heavier than is shown in the records of the previous trial of dehorning at this station. These cows also failed to regain their normal flow as quickly as was the case at other times, taking about eight days, or from two to three times as long as is usually required. The shrinkage in their milk yield was evidently almost entirely due to the effects of dehorning. Almost half of the other cows in the herd which were not dehorned at this time, gave a little less milk the first few days after the dehorning but the remainder remained stationary in their milk yield. Why the dehorning should have

affected the cows operated on so at this particular time is unknown. There was no evidence that it was more than usually painful at the time of the operation. One, No. 38, bled heavily, and acted sick for a few days, refusing her grain ration, but aside from this the cows seemed to eat well.

Most of the stations agree in saying that while the animal shows every evidence of great suffering at the time of the operation, very few of them act as though the pain continued after they were allowed their liberty. In most cases the dehorned animals would search for food, and would put in their time eating quietly at anything within reach, or they would gaze at each other as at a stranger in the herd. In one instance only, at this Station, did the dehorned cow continue to act as if in pain after the operation. She walked around the yard for a short period, occasionally shaking her head and drawing back as though flinching from the clippers. This was not long continued, however, and the cow ate her evening ration of grain very quietly two hours afterwards.

Few cattle have suffered any permanent injury from dehorning. Among many hundreds which came under the writer's observation in Illinois and Kansas, not one died. The Ohio Station reports the loss of one steer indirectly from the operation. The steer, in struggling with another member of the herd several weeks after the operation, opened the veins in the horn, and in spite of all that could be done, bled to death. A number of different remedies have been tried to prevent bleeding after the horns have been removed, but the majority of veterinarians think that it is hardly worth the trouble of doctoring, unless some particular animal shows signs of bleeding too long. There is always some bleeding, the blood usually spurting some distance, but it usually stops in a short time. Where the bleeding continues alarmingly, cotton soaked in tar or pitch and wrapped tightly to the cut surface will do as well as anything. Very few animals, however, will suffer from allowing the cut to remain without any treatment. Maggots will sometime get into the wound, or in very cold weather there would be danger of catching cold in the wound, but both of these can be obviated by performing the operation between the cold weather and fly time. This is imperative, or serious results may follow.

METHODS FOR DEHORNING.

Two general methods of dehorning exist. One is to remove the horns after the animal is past two years of age. The other is to kill the horn when it first commences to grow, or can be felt on the head of the calf. In the early history of dehorning the mature animal alone was operated on, and the instrument in common use was a sharp saw. A heavy stanchion was built with vertical and horizontal bars of heavy wood, which effectually held the animal. A halter was placed on the head, and the nose drawn up; then a strong man operated the saw, requiring a short period of time to remove each horn. There was always more or less excitement and worry connected with fastening the animal, and the operation of sawing off the horn, which required some

little time, and was certainly very painful. About 1890 the saw was gradually discarded, and clippers made especially for this purpose came into use. The use of the clippers required less preparation in the way of fastenings, and consequently less attendant excitement. No particular fastening, other than a strong halter with a turn of the rope around a solid fence post, was needed. The clippers could be slipped over the horn, and with one motion, requiring barely a second of time, the work was done, and both horns could be taken from a cow in less than half a minute. The clippers have a crshing, bruising effect, and evidently cause great pain for an instant, but it is doubtful if the pain is any more severe than when the saw was used, and the clippers require much less time for the operation. In using either the clippers or the saw it is necessary to get about one-eighth or one-fourth inch below where the skin and horn grow together to insure no further growth. Where this precaution is not taken, the horn is likely to continue to grow, and in a few years the head presents a rather undesirable appearance. Between the operation of the two instruments, the saw and the clippers, there is very little choice as regards the quality of the work done. The clippers crush the outside horn a little, and possibly do not leave as smooth a surface as the saw, but in healing this is covered up, and one is practically as good as the other.

PREVENTING THE GROWTH OF HORNS BY CHEMICALS.

As was before stated, a common method now to do away with the horns is to prevent their growth by the use of chemicals on the calf. This seems to have had its beginning about the year 1890, and immediately grew into favor. It is quickly and easily done; it is comparatively painless, causes no nervous shock, and it is done at a time when there is no milk flow to injure. The ordinary method is to use a stick of caustic soda or caustic potash when the button or small horn can first be felt, clip the hair from over the button with a pair of scissors, wet the end of the stick of caustic with saliva, and rub the skin over the horn vigorously. The operation requires about two minutes. The work can be done very easily by one man; in fact, as easily as two can do it. The best age at which to perform this operation is as soon as the button or young horn can be felt with the finger. This is usually when the calf is about a week old. But it can be done with perfect success up until the time the calf is a month old or even older, if the operator is careful to make a thorough application. A number of calves have been operated on at this Station when six weeks old, but in one or two instances they had evidently been allowed to go too long, as while one of the horns was killed by the caustic, the other one grew, giving the head a one-sided appearance; and even if the growing horn is clipped off after it gets its growth, the head will not present an even appearance, as can be judged from the heads given in the illustration in this bulletin. It is better to use the caustic on the calves when they are young enough to insure that the operation will be effective, and this age is from three days to

three weeks. As it would save time and material to operate on a number of calves at the same time, it might be well to allow the first calves to reach the limit of age. In our work at this Station we have used the stick caustic potash or caustic soda entirely, and in its use we necessarily handle it with care, never allowing it to come in contact with the finger, as it has a burning or corroding effect, and will take off the skin very quickly. This can be prevented by simply wrapping the end of the stick in a piece of paper to serve as a handle. In applying the caustic to the head, it is well to not allow the spot to become too moist, as it will run down the side of the head, making a sore, removing the hair, and leaving a scar which may show—and, then, there is danger of it running into the eye which would certainly cause blindness. It would be well to have some water standing close, so that the caustic could be dipped into it a couple of times during the application. In using the caustic, thorough rubbing is necessary, and insufficient rubbing has caused many failures. It is well to rub until the skin over the horn commences to look red, as though the blood was about to start. This will take from fifteen seconds to one-half minute to each horn.

There is, of course, some pain caused to the young calf by the use of the caustic, as it has the effect of entirely burning away the skin from over the horn. But this pain is not in the nature of a violent nervous shock, as must be caused by dehorning clippers on the mature animal, and there is no loss of blood. There can be no possible danger from its use. For a short time after the application, the calf goes around shaking its head, but they never refuse to eat immediately after, when the pain is the greatest. How long the pain lasts is a matter of conjecture. Perhaps an hour, possibly longer. In some instances the calf shows no sign of suffering after fifteen minutes are passed. The operation appears to be more humane than removing the mature horn, and it doubtless is so. It at least has not aroused the criticism of any body of persons. The head of the animal dehorned with a chemical presents a much different appearance from one dehorned with clippers. In a neat job with chemical dehorner, it would be difficult to distinguish between it and the head of an animal of the polled breeds. When the clippers are used, the head presents a square appearance rather unnatural for an animal without horns, and yet many prefer it to the rather pointed head of the polled breeds or the animal dehorned with chemicals.

Since caustic potash or soda came into general use a number of so-called patent dehorners have been placed on the market. These are nearly always fluid, coming in small bottles. In a number of cases analyses have shown them to be simply saturated solutions of caustic soda. They are sold at fancy prices, usually at from five to twenty times the value of the original material. It is more economical to buy caustic soda or potash in sticks costing about 25 to 30 cents a pound, and a pound will dehorn a hundred calves or more. A number of patent dehorners have been tried at different places with varying results, and while a few will do what is claimed for them, others

FIG. 1.—POLLED ANGUS.

FIG. 2.—DEHORNED WITH CLIPPERS.

FIG. 3.—DEHORNED WITH CAUSTIC.

have failed entirely, or have met with indifferent success. Out of four tried by the U. S. Department of Agriculture, only one proved as effective as the stick potash or soda. The U. S. Department of Agriculture prepared a dehorner, using fifty parts of caustic soda, twenty-five parts of kerosene and twenty-five parts of water. The caustic soda and kerosene were made into an emulsion by heating together, and this was added to the water. It was found to be effective.

Where the caustic soda or potash is used it should be kept in an airtight bottle, as it absorbs moisture from the air very rapidly, and becomes difficult to handle. Just sufficient for the calf or calves that are to be dehorned should be removed from the bottle, and what remains after the operation is finished should be thrown away or placed in a small bottle by itself, so the collected moisture cannot come in contact with the dry sticks in the unused portion. A little experience in the use of potash makes its use more effective and rapid.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 79. JANUARY 1902.

THE DISINFECTANT PROPERTIES OF WASHING POWDERS

By C. F. Doane.

There has always been a pressing need for some chemical compound with strong antiseptic properties which could be safely used in the cleaning and sterilizing of utensils for the handling of food products.

There are a number of disinfectants which can be applied to almost every other condition than where they come in direct contact with the kitchen and dairy utensils. In surgical work or sterilizing surgical instruments carbolic acid 5 parts to 100 parts of water or 1 part of corrosive sublimate (mercuric chloride $HgCl_2$) to 1000 parts water is very effective. In disinfecting sick rooms formaldehyd, sulphur, or carbolic acid is employed. The objections to using any of these around a dairy or kitchen is apparent to anyone who understands their characteristics. Corrosive sublimate is one of the most violent poisons known, requiring but a very small amount in the stomach to cause quick and sure death. The fact that it is entirely odorless and tasteless makes its use even more dangerous, and to wash food utensils in a solution of it would be the greatest folly, even were the utensils thoroughly rinsed out after the use of the sublimate solution.

Carbolic acid is likewise a poison, though not nearly so violent as corrosive sublimate. In addition to being a poison it has a very characteristic and persistent, and to some, offensive odor and taste. Its use in a dairy even for disinfecting drains would be unadvisable because of its strong odor which would soon taint the milk. While formaldehyd and sulphur are used in the form of gas and fumes which would taint any food product with which they might come in contact.

Corrosive sublimate would do very well for disinfecting drains were it not for the fact that it is so violently poisonous that its use in any place where there is a possible chance for its getting into the milk or food is unadvisable. Caustic lime, the ordinary unslacked lime of commerce, is often used with good results in cess pools and closets for disinfecting and suppressing offensive odors, but it requires such a large quantity that its use in a dairy is impractical.

In common practice almost the only thing which has ever proved efficient and unobjectionable is scalding water or steam. In dairy work where there is a large number of cans, buckets and strainers to wash it requires considerable time and work to thoroughly scald

them all with boiling water and be sure that all have been rendered sterile. Moreover, unless the greatest care is exercised the last utensils treated will be very poorly sterilized. The water may be boiling when it is poured into the first can, but by the time it has been poured into a number of cans and allowed to stand for a sufficient length of time to kill the greater number of germs present it will become so cool as to have no effect whatever on the bacteria, other than to wash out a few as it is poured from can to can. Then, too, in using scalding water the person doing the work is likely to get in too much of a hurry, or become careless and not allow the water to remain a sufficient length of time to thoroughly do the work intended for it. About the only way in which boiling water could be satisfactorily applied to a large number of cans would be to have it in a large reservoir or one of the large old-fashioned iron kettles and thoroughly immerse each can and bucket in it. This would require considerable water and fuel for heating.

At this Station as well as in a large number of creameries and in private dairies all cans and buckets are thoroughly scalded with steam on the inside. Near the sink where the tin ware is washed a-half inch pipe is run from beneath through a table, leaving the open end stick out two inches above the surface of the table. This pipe is fitted with a valve and is connected directly with the boiler in winter and a water heater in summer. The cans after being washed are turned bottom side up over the end of this pipe and the steam or boiling water is turned on by the valve. Half a minute of this treatment is thoroughly efficient as far as all practical purposes are concerned. It is easy to manipulate, requires very little, if any, extra time, and is entirely satisfactory in every way. Such an arrangement, of course, requires either a steam boiler or water under pressure and as the necessary fittings for either are rather expensive but very few of the private dairies could be supplied in this way. This leaves boiling water as about the only disinfectant for use under ordinary circumstances, and hot water is so carelessly used as to make it valueless in the majority of cases.

A disinfectant for use either in the dairy or kitchen must have a number of qualifications. It should, of course, be reasonably effective. By this it is not meant that it necessarily should kill the spores of the more resistant bacteria, as where it becomes necessary to thoroughly disinfect, some extra precautions could be observed and either corrosive sublimate or formaldehyd used. But the disinfectants should have the power of killing all of the growing forms of germs and a large part of the spores. The disinfectants should be odorless and practically tasteless, as milk would otherwise be easily tainted and rendered unfit for use. It should, of course, be non-poisonous in small quantities, as where a disinfectant is in general use around a dairy or kitchen there is always the danger that sometime a small portion may get into milk or food. For general use, the disinfectant should be cheap and it should not be necessary to use a large

quantity to accomplish the purpose for which it is intended. If it has cleansing properties as well as antiseptic properties it is all the better.

Work to determine the antiseptic properties of different chemical compounds has been carried out with most of those which would be likely to have such properties. Among other compounds tried some work has been done to determine the effect of solutions of soap in water on bacteria. It was found that a 5 per cent solution of soap would kill practically all germs in a short period of time. The work done by the soap was not very extensive, but one or two different makes being experimented with. It would naturally be supposed, however, that as all soap is made in the same way from practically the same materials, all would have the power to kill germs to some entent. What gives the soap this antiseptic property has not been entirely explained. It is well known that all caustic alkalies have the power of killing germs. Soap is a combination of caustic alkali with fat. The combination of the fat with the alkali set free glycerine. In nearly all soaps there is a small portion of free alkali, as enough fat is not used to combine with all the caustic, with the result that part of it remains in its original form with any germicide properties entirely unimpaired. If it is the free alkali which gives it antiseptic properties the amount contained by the soap would determine the proportion of soap necessary in a solution to be effective. Soaps vary in the amount of free alkali contained. Those made for laundry and kitchen use have a relatively large proportion, while toilet soaps have very little, if any, as its presence is known to make the skin hard and dry. The experiments carried out did not mention the soaps used. They were very likely the laundry or kitchen variety. But it will develop from work done at this Station that the toilet soaps could well have antiseptic properties, as in the work done here it was found that washing powders had this property to a greater extent than could be accounted for by the amount of free alkali they contained. Either the glycerine or the salts of the alkali and fatty acids which form the greater part of soap must have the power of killing germs to a considerable degree.

The first work done at this Station to determine the antiseptic properties of washing powders was about three years ago and was done with the idea of trying to find something which would partially fill the requirements for a good disinfectant for dairy and kitchen use. The laboratory facilities for doing bacteriological work at this Station at that time were very limited and the work after being partially done was deferred. During the last few months it was taken up again under more favorable curcumstances and completed.

It is not expected that the work will add anything new to science or be of any value to purely scientific workers, as none of the more resistant forms of spores were experimented with to determine the actual antiseptic value of the washing powders as compared with the well known and tried disinfectants. This phase would be interesting but we did not have any pure cultures of the germs ordinarily used for this purpose at hand. It is believed, however, that the work done

was entirely practical and thorough, and was sufficient to determine the value of the washing powders for the use for which they are here recommended.

Washing powders have been on the markets for a number of years. They are advertised for washing and scrubbing purposes only, and their value for this is pretty thoroughly established. Their composition has been kept more or less secret, but chemical analysis made at this Station showed them to be composed of 80 per cent of soap and 20 per cent of free alkali, the alkali being caustic soda. One analysis of a well known and very efficient brand showed the yellow or golden tinge to be due to coloring matter added to the fat used in making the contained soap. The coloring matter was evidently such as might be used for coloring butter, and very likely either oil of anatto seed or some analine dye. This made the washing powder distinct in color from any of the other brands, without affecting its value as a cleansing agent in the least. It is likely that the great majority of the washing powders have practically the same composition as those of which we made an analysis, varying slightly perhaps in the proportions of soap and free alkali, but not enough to very materially influence the actual value.

The work done at this Station was to determine the value of washing powder as disinfectants, and, if they had such value to determine which was the more efficient. As was before stated, it was decided to make the test as practical as possible, having the conditions such as they would be in the use of the substance in actual practice. As we were interested in the use of washing powders in the dairy the particular point to be decided was the effect of these powders on the germs which are found in milk, and the experiments were planned to test this particular point.

The work was carried out as follows: A measured quantity of milk, from .1 to .5 cc. (cubic centimeters) was put into 5 cc. of sterilized water. For the control sample a measured quantity of the water and milk was put into another 5 cc. of sterilized water and then a measured quantity was added to each of two tubes of melted lactose agar. The number of germs developing from this can be seen under the column headed "Water blank" in the tables. The same quantity was taken a second time from the first mixture of milk and water and put into 5 cc. of a solution of a weighed quantity of washing powder and water either hot or cold and a measured quantity of this mixture was added to the melted agar at stated intervals. One sample was taken as soon after the milk and water mixture had been added as possible, but a few seconds elapsing. The result of this can be seen in the column in the tables headed "Taken immediately." Another sample was taken at the end of five minutes, and still another and the last at the end of ten minutes and the results of each of these can be seen in the tables in the columns under their respective headings.

With each washing powder tried, the solution of the washing powder and water was used both warm and cool. The cool water

was at almost average room temperature. The milk and water mixture that had been used for the control sample was added to the 5 cc. of washing powder solution in the test tube when the solution was at 130 F which is too low a temperature to kill quickly more than a minimum number of the germs contained in the milk and water mixture. As this was allowed to stand in open air it cooled very rapidly and by the end of ten minutes when the last sample was taken it had reached a temperature below 100 F. In ordinary practice the solution would not cool so rapidly except when it was used for scrubbing floors and woodwork, in which case the first effect of the heat would be all that would be gained.

A solution of one gram of washing powder to 300 cc. of water was first tried but as this did not seem to be sufficient to thoroughly do the work, 1 gram to 150 cc. of water was then used. One gram of washing powder to 150 cc. of water would be at the rate of one pound of powder to 150 pounds of water, or one pound of powder to a little over seventeen gallons of water. As washing powders cost only about six cents a pound retail, or five cents a pound in large quantities it can be seen that so far as price is concerned they would make a desirable disinfectant. Carbolic acid has to be used at the rate of 5 pounds to 100 pounds of water, and, while corrosive sublimate is used at the rate of 1 to 1,000 it is quite expensive. It is not to be expected that the washing powders in the quantities advised in this bulletin would be efficient as 5 to 100 of carbolic acid, but the tables will show that for practical purposes outside of disease and surgery they are effective.

As savogdran has often been recommended as a good washing powder, and as it was being used at this Station at the time, it was the first experimented with. As was stated before, 1 gram in 300 cc. of water was tried first, the solution being used both cold and warm; then 1 gram to 150 cc. of both hot and cold water was tried. The effect of using 1 to 300 can be seen in table I.

TABLE. I.

One gram Savogdran in 300 cc. Cold Water.

	Colonies in plate Water Blank	Colonies in plate Taken Immediately	Colonies in plate End 2 Minutes	Colonies in plate End 5 Minutes	Colonies in plate End 10 Minutes
1st trial	140	20	20	10	10
2nd trial	915	435	425	370	365
3rd trial	220	215	175	75	18
4th trial	360	78	46	55	27

One gram of Savogdran in 300 cc. Warm Water.

1st trial	1,480	00	00	00	00
2nd trial	740	35	22	11	00
3rd trial	437	64	15	7	5
4th trial	130	28	8	2	0

Table I. shows that when the solution was used cool, 54 per cent of the germs were killed in the part taken immediately from the solution. A few more were killed by being allowed to remain in the solution for a longer period. However, it would hardly be termed effective. When the water and milk mixture was added to the warm solution, 95 per cent of the germs in that taken immediately were killed and the number of germs was continually reduced the longer they remained in the solution until at the end of ten minutes in only one case were any left alive and then but 5 out of nearly 500 in the water blank remained. These 5 developed very slowly in the plates and very likely were in the spore stage of some very resistant species. It will be noticed that in the first trial with the warm solution all germs were killed. This was the only case where a pure culture was used in place of milk. The germ was a cocci, evidently not having very much resistance to disinfectants. Table I. shows the warm solution of 1 gram of Savogdran to 300 cc. of water to be fairly effective as a disinfectant, especially where it has been allowed to remain in contact with the germs for a number of minutes.

One gram of savogdran was then tried in 150 cc. of water, the solution being used both hot and cold. The result of this stronger solution can be seen in Table II.

TABLE II.

One gram Savogdran in 150 cc. Cold Water.

	Colonies in plate Water Blank	Colonies in plate Taken Immediately	Colonies in plate End 2 Minutes	Colonies in plate End 5 Minutes	Colonies in plate End 10 Minutes
1st trial	6,000	340	112	85	33
2nd trial	140	100	60	40	10
3rd trial	1,500	5	4	0	0
4th trial	435	45	12	8	0

One gram Savogdran in 150 cc. Warm Water.

1st trial	200	20	10	5	0
2nd trial	560	20	18	4	0
3rd trial	280	18	9	5	0
4th trial	340	25	15	3	0

The table shows that when the solution was used cool an average of 94 per cent of the germs were killed when removed immediately from the solution and the number steadily increased until the last samples were removed at the end of ten minutes when more than 99½ per cent were killed and in two of the four trials, all were killed.

When the solution was used at a temperature of 130 F. an average of 94 per cent of the germs were killed when removed immediately from the solution and an average of 96 per cent were killed at the end of two minutes while all were killed at the end of ten minutes. As had been the case when 1 gram to 300 cc. of water was used the germs which grew after having remained in the solution for a number of minutes developed very slowly in the plates, and very likely were either spores or had been seriously affected by the solution.

The savogdran which was used in these experiments had been on hand for some time in a keg which, while it was kept covered, was not air tight. It is possible, even likely, that it had deteriorated somewhat in contact with the air, the free alkali forming a carbonate and thereby partially destroying its antiseptic properties. It certainly did not do as well as the other powders tried which were used in the fresh state.

Gold Dust was the next washing powder experimented with as it is widely advertised and has come into frequent use in dairies. It, like the savogdran was used first at the rate of 1 gram to 300 cc. of water; the solution being tried both hot and cold. Table III. shows the result.

TABLE III.

One Gram Gold Dust in 300 cc. Cold Water.

	Colonies in plate Water Blank	Colonies in plate Taken Immediately	Colonies in plate End 2 Minutes	Colonies in plate End 5 Minutes	Colonies in plate End 10 Minutes
1st trial	845	670	112	64	18
2nd trial	84	5	5	2	00
3rd trial	82	5	8	6	2
4th trial	144	18	6	2	1

One gram Gold Dust in 300 cc. Warm Water.

1st trial	246	00	0	0	0
2nd trial	85	10	0	0	0
3rd trial	146	18	3	2	0
4th trial	322	6	2	0	0

With the cold solution about 40 per cent of the germs were killed when removed immediately from the solution. This low per cent is due largely to the poor showing made in the first trial when not more than one-fourth of the germs removed immediately were killed. Calculating on the basis of the other three trials about 90 per cent were killed. The average of the four trials shows that an average of 98 per cent were killed in ten minutes.

With the use of the warm solution 96 per cent of the germs taken immediately were killed, and all which remained in for ten minutes were killed, while in three trials all were killed in five minutes. This is an excellent showing and would prove that for practical purposes gold dust at the rate of 1 to 300 is a good disinfectant for dairy use.

As 1 gram of gold dust in 300 cc. of water in a warm solution was found to have sufficient antiseptic properties for practical purposes 1 gram in 150 cc. of warm water was not tried. But 1 gram in 150 cc. of cool water was tried and Table IV. gives the result.

TABLE IV.

One Gram Gold Dust in 150 cc. Cold Water.

	Colonies in plate Water Blank	Colonies in plate Taken Immediately	Colonies in plate End 2 Minutes	Colonies in plate End 5 Minutes	Colonies in plate End 10 Minutes
1st trial	488	1	0	0	0
2nd trial	86	11	4	1	0
3rd trial	150	17	3	0	0
4th trial	680	45	9	2	0

Table IV. shows that in the cold solution of 1 gram in 150 cc. of water 95 per cent of the germs taken out immediately were killed, while all were killed in ten minutes, and all but a total of 3 in the four trials were killed at the end of five minutes.

Pearline was the third and last of the so-called washing powders experimented with. The work with it was done in the fall of 1901, more than two years after the previous work. Enough work was repeated with both the gold dust and savogdran at this time to insure that their value as disinfectants had not been overestimated, and that the previous trials had been substantially correct in results. Pearline was used in the same proportions and in both hot and cold solutions. The result of using 1 gram to 300 cc. of water can be seen in Table V.

TABLE V.

One Gram Pearline in 300 cc. Cold Water.

	Colonies in plate Water Blank	Colonies in plate Taken Immediately	Colonies in plate End 2 Minutes	Colonies in plate End 5 Minutes	Colonies in plate End 10 Minutes
1st trial	24	3	3	4	3
2nd trial	620	62	6	1	1
3rd trial	340	28	14	4	2
4th trial	825	130	26	8	0

One Gram Pearline in 300 cc. Warm Water.

1st trial	10	2	1	0	0
2nd trial	620	9	1	3	0
3rd trial	24	5	6	2	0

With a solution of one gram of pearline in 300 cc. of cold water 93 per cent of the germs removed immediately were killed and but three in the four trials were alive at the end of ten minutes. With the same strength of solution used hot 98 per cent of the germs removed immediately were killed. But three trials were made with the solution as the results have come out practically the same with the other washing powders and an analysis had shown its composition to be practically the same as that of the others. But two trials were made with 1 gram to 150 cc. of water, the result of which can be seen in Table VI.

TABLE VI.

One Gram Pearline to 150 cc. Cold Water.

	Colonies in plate Water Blank	Colonies in plate Taken Immediately	Colonies in plate End 2 Minutes	Colonies in plate End 5 Minutes	Colonies in plate End 10 Minutes
1st trial	40	0	0	0	0
2nd trial	83	6	2	0	0

One Gram Pearline to 150 cc. Warm Water.

1st trial	40	0	0	0	0
2nd trial	96	0	0	0	0

Table VI. shows that where the solution was used cold 95 per cent of the germs were killed when removed immediately, and all were killed at the end of ten minutes. With the hot solution all germs were killed in the samples removed immediately.

It may be urged that the increased alkalinity of the culture media due to the adding of the small quantity of washing powder solution may have interfered with the development of the germs. But .1 cc. of the solution was added to 6 cc. of the culture media, and when titrated it was found that the alkalinity had increased but a very little after adding that quantity of the solution. Moreover, it will be noticed that in a few cases a large number of germs developed. The adding to the solution to the media may have interfered with the growth of the germs, which is doubtful, but if it did, the results as shown by the plates would prove that the solution was a very good antiseptic and its presence even in minute quantities would check the growth of germs. This fact would make its use very desirable.

As has been stated before, it is doubtful if washing powders will ever supplant the better known disinfectants in surgical cases or contagious diseases. They can find a useful field in the dairy and kitchen where the use of all the other disinfectants are either objectionable because of their odors, or dangerous because they are poi-

sonous. In the large creameries where more or less milk is always slopped around and soaked into the woodwork an application of a hot solution of washing powder at the rate of one pound to about 25 gallons of water will effectively check any tendency to disagreeable odors such as are common to nearly all large creameries in the summer months. It is difficult, if not impossible, to render everything thoroughly clean in the majority of cases. A good disinfectant will help materially. These washing powders are already used in creamery work to a great extent because of their cleansing properties. The hot solution is applied vigorously with a brush and then everything is thoroughly flushed down with clean water. If the rule was reversed the treatment would be more effective. The floors and the woodwork should be gone over well with hot pure water and then covered with the hot water containing the washing powder which should be allowed to remain. It is odorless and the longer it can be allowed to remain the more germs it will kill, and after all, it is largely the germs which develop in dirty floors and get into the cream and milk that cause the damage more than the dirt itself. Washing powders can also be employed instead of steam or scalding water for sterilizing tinware and handling milk. A good plan would be first rinse the can free of all milk by the use of cool water and wash with warm water. Then add a solution of the washing powder to the can, thoroughly shake it up to be sure that it touches every part of the can, and go through all the tinware used in that way and then after the first can has stood for five or ten minutes rinse it with clean well water. This will insure tinware as thoroughly sterilized as it would be were it turned over a steam jet for a few seconds. The solution is tasteless unless very strong, and it is easily rinsed free from tinware, so there is no danger of its tainting or injuring the milk. As was stated before, the steam jet is handy and it is preferable, but where steam is not to be had without considerable expense the solution of washing powder will do as good work though requiring a little more time and handling the vessels treated.

The choice of washing powders is more a matter of price than brand as it is doubtful if there is one with any more merit than a number of others. But the buying of washing powders in large quantities is to be cautioned against. The free alkali forms a carbonate in contact with the air which decreases its value very materially. Large creameries which use the powder in quantities could buy by the keg but in small dairies or for household use it is better to buy in packages at wholesale prices by taking 100 pounds. If these packages are airtight they will keep very well through a number of months.

SAL-SODA OR WASHING SODA.

As washing soda is used very extensively in dairies for scrubbing purposes a number of experiments were carried out with it to determine if it had the same antiseptic properties as the soap powders or washing powders. Practically the same experiments were con-

ducted with it as it was used in both hot and cold solutions. One gram of 150 cc. of water was tried first, and as it did not have the desired effect it was thought useless to try the soda in the proportion of 1 gram to 300 cc. of water. The result of the trials with 1 gram of the washing soda in 150 cc. of water can be seen in Table VII.

TABLE VII.

One Gram Washing Soda in 150 cc. Cold Water.

	Colonies in plate Water Blank	Colonies in plate Taken Immediately	Colonies in plate End 2 Minutes	Colonies in plate End 5 Minutes	Colonies in plate End 10 Minutes
1st trial	1,840	1,425	674	236	45
2nd trial	660	19	12	2	00
3rd trial	324	115	38	12	12
4th trial	478	89	64	18	00
One Gram Washing Soda in 150 cc. Warm Water.					
1st trial	1,800	110	10	8	7
2nd trial	598	14	11	5	2
3rd trial	439	18	8	7	3
4th trial	168	12	7	3	0

Table VII. shows that with the cold solution but 50 per cent of the germs removed immediately were killed and 98 per cent were killed at the end of ten minutes. With the warm solution 95 per cent of those removed immediately were killed and only in one trial were they all killed at the end of ten minutes. The principal objection to washing soda is that it deteriorates so fast that it requires frequent purchasing of new material to keep it efficient. In contact with the air it loses its water of crystalization and crumbles away to a white powder that actually interferes with the washing of tinware by settling on the surfaces. Were it not for this characteristic it would doubtless be about as desirable as any of the so-called washing powders which do not have this objectionable quality to such a marked degree.

BAKING SODA FOR WASHING.

The ordinary baking soda is often recommended for washing purposes. It is claimed by many writers to be especially valuable for cleaning children's nursing bottles after the milk has been allowed to sour in it. A few trials were made to determine if the baking soda had any antiseptic properties. One gram to 150 cc. of water was first used in both the warm and cool solutions and Table VIII shows that

in neither case was there any effect whatever on the number of germs present. There was as many germs developed in the plates from the samples taken from the water blank. Eight germs of the soda was tried in 150 cc. of cool water. With this amount about 25 per cent of the germs removed immediately were killed and at the end of ten minutes about 97 per cent of the germs had been killed. This is not as good showing as that made by the washing powders at the rate of 1 gram to 150 cc. of cool water. It is rather hard to understand just why baking soda should be considered a good cleansing agent. It could not have any of the properties of soap, and very few of those of free alkali. It has the power of combining wih the lactic acid which gives the dirty bottle its sour odor, and would destroy this odor. This quality is objectionable, however, as it would lead one to believe the bottle clean when it was not clean, in much the same way as perfume makes an unwashed person less objectionable. A small quantity of washing powder would be more efficient in cleaning the dirt from the bottle and would thoroughly sterilize it at the same time.

TABLE VIII.

One gram of baking soda in 150 cc. cool water, had no effect on the number of germs.
One gram baking soda in 150 cc. warm water, had no effect on the number of germs.

Eight grams baking soda to 150 cc. cool water.

Colonies in plate water blank	Colonies in plate taken Immediately	Colonies in plate end of 2 min.	Colonies in plate end of 5 min.	Colonies in plate end of 10 min.
804	610	196	77	27

TABLE IX.

Trials of Pure Caustic in Solutions.

Caustic Soda, 1 to 2,000, warm; had no effect.
Caustic Soda, 1 to 1,600, warm; had no effect.

Caustic Soda, 1 to 800, Warm.

Colonies in plate Water Blank	Colonies in plate Taken Immediately	Colonies in plate End 2 Minutes	Colonies in plate End 5 Minutes	Colonies in plate End 10 Minutes
20	11	9	8	6

To determine if the free alkali in the washing powders was entirely responsible for their antiseptic properties a couple of trials were made with caustic soda. As the washing powders contain about 20 per cent of caustic soda at the rate of 1 gram of washing powder to 150 cc. of water would be in about the proportion of 1 part of caustic soda to 800 parts of water, and 1 gram of washing powder to 300 cc. of water would be at the rate of 1 part of caustic to 1,600 parts of water. Table IX shows the proportions of the pure caustic used and the results, and these results would show that something else aside from the 20 per cent of the free alkali in the washing powders increased its antiseptic properties to a very marked degree..

THE MARYLAND

AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 80. FEBRUARY, 1902.

ACUTE EPIZOÖTIC LEUCOENCEPHALITIS IN HORSES.

By W. G. MacCALLUM, M. D.,
Associate in Pathology, Johns Hopkins University,
and
S. S. BUCKLEY, D. V. S.,
Veterinarian Maryland Agricultural Experiment Station.

(From the Journal of Experimental Medicine, Vol. VI., No. 1, November, 1902.)

INTRODUCTORY NOTE.

The disease of horses, so well known on the Eastern Shore and in the lower counties of Maryland as "Cerebro-spinal Meningitis," "Staggers" and often simply as the "Horse Disease," has been claiming the attention of the Veterinary Department of the Experiment Station for several years.

It has appeared at irregular intervals and its continuous study, therefore, has been impossible; yet, it has been present more or less, at some place in the State each year.

Many outbreaks of this disease have been reported and commented upon from all parts of the country, and all have failed to throw any light upon the nature, cause or means of combating it. This is not remarkable, however, when we consider the short duration of an attack and the difficulty experienced in reaching the cases promptly.

Bulletin No. 53 of this Station gives a brief description of its symptoms. In summing up the post-mortem appearances in that report, we find but little if anything which would indicate serious disturbances in the body organs. Similarly, all reports upon this disease, from all sources and under any of its many names, fail to note tissue changes or lesions, commensurate with the intense suffering, varied symptoms and fatal termination. So that practically nothing is known beyond the symptoms, and the probable termination of an attack.

The outbreak occurring in the late fall and winter of 1900-1901 was especially severe, and furnished the first evidences of a constant

tissue change. The determination of this lesion led to the co-operative work of the Pathological Department of Johns Hopkins University and this Station. Unfortunately, this discovery was not made until the disease had ceased, practically, to exist, and since that time only three or four cases have been available. We know now, positively, where the diseased area exists and its nature. The accompanying text furnishes the detailed description of the changes that take place in the tissues. It yet remains to find the cause for this destruction of brain tissue and the means of preventing the disease. It is evident from an examination of Plate III, Fig. 7, that there is no possible hope for a cure, in such an advanced case as this represents.

Further investigations necessarily depend upon the existence of affected animals, their observation during the course of the disease and their examination after death. This work can be greatly augmented by having prompt reports of the existence of this disease anywhere in Maryland and communications from those interested in the solution of its problems are cordially invited.

S. S. B.

Plates I, II and III.

A recent epizoötic among horses in Maryland, resulting in the death of a great many animals after a very brief illness, has led to the post-mortem examination of a number of such animals with results which seem worthy of note.

The disease, which is popularly known in this region and probably elsewhere as "cerebrospinal meningitis," presents fairly characteristic symptoms, which when the cases appear in epizoötic form lead readily enough to a diagnosis. Prodromal symptoms are not always present, although in many cases a general malaise may be noted before the acute onset. The acute symptoms are in general such as may be referred to a cerebral lesion. There may be drowsiness associated with an impairment of sight. Partial or complete paralysis of the pharynx is often observed; twitching of the muscles of the shoulders and thighs, coldness of the extremities, and a general condition of unsteadiness and weakness with a tendency to walk to one side or a staggering, objectless gait, arise early in the disease. The pulse is usually normal; the temperature varies between 96 and 103 degrees F., an elevated temperature usually indicating a secondary complication.

The horse may then become gradually comatose, responding slightly or not at all to stimuli and soon sinking to the stable floor not to rise again. In other cases there is a wild delirium, the animal rearing about and rushing blindly against obstacles, and this may be followed by exhaustion and the comatose condition.

The duration of the disease varies from a few hours to a week, the average being perhaps 72 hours. Horses which recover are said to become "dummies"—animals with a permanent cerebral lesion and defective intelligence.

The following pathological report is based on the examination of four brains, brought to the laboratory by one of us (Buckley), from animals dying in the acute stages of the disease. There was also one brain from a horse which was said to have had the disease some time before and to have recovered, dying afterward from some other cause.

PATHOLOGICAL REPORT.

Of the four brains from acute cases, three were hardened in formalin and one was fresh. Of these, none showed any signs of the presence of an inflammation of the meninges; there was at most a trifling hyperaemia of the pia mater. The surface of the fresh brain showed no localized or circumscribed alterations in color, but the normal level of the convolutions was not everywhere preserved. In the frontal region on each side, anterior to the motor region of the cortex, there was a slightly depressed area which was softly fluctuant, but not marked out by any superficial hyperaemia or discoloration. On cutting through this brain a glairy fluid with small granular pulpy masses of whitish tissue flowed out from the softened area, and the rather thin roof composed of the meninges with the grey cortex collapsed over the cavity thus left. The lesion seemed almost entirely limited to the underlying white matter, which throughout an irregular area, perhaps 2x1 cm. in diameter in the left hemisphere, and a symmetrically placed focus 5 cm. in diameter in the right, was completely softened into a diffluent mass made up as described of shreds of softened, necrotic-looking, greyish white brain substance lying in a greyish, glairy or somewhat glutinous fluid. The portions of the brain substance forming the lining of the cavity could be fairly sharply outlined from the adjacent more normal white matter by its softness and raggedness, by its mottled greyish and yellowish opacity with translucent areas, and by the presence of numerous minute hæmorrhages sprinkled through it and adding to its mottled appearance. The remaining brain substance showed no apparent abnormality. The lining of the cerebral and olfactory ventricles was not congested nor inflamed. The blood vessels were carefully traced and showed no thrombotic occlusion at any point.

Examined microscopically in the fresh state, the softened material showed necrotic cells and cell fragments of various forms; there were also beaded elongated fibrils thought to be axis cylinders with adhering myelin droplets. But few nuclei were found. No bacteria were found by the ordinary staining methods.

Cultures were made aërobically and anaërobically on various media —agar, glycerin agar, blood-serum agar, hydrocele-fluid agar, etc.— but all were negative. A rabbit inoculated with 1 cc. of an emulsion of the softened material into the ear vein remained well.

The appearance of the hardened brains corresponds very closely with that just described. Nowhere were any blood-vessels thrombosed or occluded in any way. Nowhere was there evidence of inflammation of the meninges. Section of the cerebral hemispheres showed irregular

areas in the white matter of the occipital as well as the frontal lobes, and once in the temporal lobe, in which the brain substance had been softened and partly replaced by a translucent coagulated substance resembling agar. Shreds of greyish brain substance coursed through this clear gelatinous material. The adjacent greyish and opaque brain substance was studded with hæmorrhages through a thickness of about 3 mm. Where, as in some cases, the areas of softening were made up mainly of the greyish necrotic brain substance without much collection of fluid, the haemorrhages were scattered throughout. In no instance did the cortical grey matter appear to be implicated, nor were the basal ganglia invaded.

Microscopically the lesions are practically identical in all the four cases except that while in all the process is quite acute, in one the destruction was less complete than in the others and the replacement of the necrotic material by coagulable fluid less extensive. A general view of a section carried through the cortex into the centre of such a focus shows the meninges practically normal, the elements of the grey cortex not notably altered, the nerve cells staining well, the blood-vessels patent and filled with blood. Passing inward the nervous elements begin rather abruptly to degenerate, disintegrate and disappear, and haemorrhages begin to occur here and there; further toward the centre no more nerve cells are visible, axis cylinders are much degenerated, neuroglia cells stain badly, and the tissue has a much disintegrated appearance, being infiltrated with not very numerous polymorphonuclear leucocytes and fewer mononuclear round cells. Still further, and all evidence of tissue, except for small islands of necrotic substance, disappear in the highly refractive vacuolated hyaline material described (Plate I, Fig. 1). We have then to consider in detail:

1. Changes in nervous elements.
2. Changes in neuroglia.
3. Changes in blood-vessels.
4. Changes in lymphatics.
5. Exuded fluid and cells.

The pyramidal ganglion cells which send down their axis cylinders through the degenerated area appear normal in the uninvolved portion of the cortex. The periganglionic cells may perhaps be more than usually numerous. In the lower layers as one approaches the degenerated area the ganglion cells become swollen and granular, the nucleus stains less sharply, and the cell processes, so definite in the higher layers, have been lost or disappear after a very short course, forming mere projections from the outline of the cell. Many such cells take on a rounded outline and appear now as large, irregularly rounded, granular cells with rather diffusely staining nucleus. Indeed, as in Fig. 6 (Plate III), such cells may be seen in the same field with their disintegrating processes which are slightly separated from the cell body; others still more degenerated have lost their nuclei. The much-degenerated cells lie in a tissue of axis cylinders and neuroglia

which is thickly sprinkled with globules of various sizes of high refractive index and staining faintly bluish with haematoxylin. In specimens stained by Weigert's method these globules take the typical myelin stain.

The axis cylinders are somewhat swollen and thick and show evidences of disintegration (Plate II, Fig. 5). They persist, however, fairly well into the completely necrotic substance, where they end abruptly. Throughout the degenerated area their myelin sheaths are broken up into the globules described above, many of which adhering to the axis cylinders give rise to the varicose appearances or bulbous swellings along the course of the fibril. In specimens prepared by Marchi's method such varicose beaded masses often stain black.

The neuroglia has also suffered severely. Traced by the aid of Mallory's special methods from the relatively normal cortex toward the centre of an area of softening, the dense matted feltwork of the outer region is seen to give place to a delicate network of finer deeply staining fibrils, which in their turn completely disappear further toward the centre, leaving the material there without any definite neuroglia stain and consisting of necrotic debris of cells and tissue without connecting supporting substance. Associated with this gradual disintegration of the neuroglia feltwork there are changes in the neuroglia cells. These lose the sharp contours of their nucleus, which comes to stain a diffuse greyish purple without any sharply stained chromatic particles; such nuclei become more and more indistinct and finally disintegrate.

Even more striking than these destructive degenerative changes in the nervous elements and the neuroglia cells and fibrils are the changes in the blood-vessels of the affected area.

It was stated above that examination of the vessels macroscopically and with scissors failed to reveal anywhere the presence of an occluding thrombus or embolus. Sections, too, made to pass through the blood-vessels in those brains already hardened when brought to the laboratory showed them to be filled only with blood. In the area of degeneration, however, wherever small vessels are left they may sometimes be found filled or partly filled with an elongated highly refractive hyaline mass, the free ends of which may be rounded off or pass over insensibly into the adjacent compressed and coalescing red blood-corpuscles. Such hyaline formations have been found mainly in the smallest vessels and in the degenerated area. Sometimes the lumen is only partly filled and the hyaline material may show gaps in which lie red corpuscles (Plate I, Fig. 2), or it may form a thick bluish-staining lining for the vessel in the lumen of which lie the red corpuscles.

The walls of the vessels in these areas show, however, extensive inflammatory changes. They are infiltrated (Plate II, Fig. 4), with cells of the type of the polymorphonuclear leucocyte for the most part, but occasionally mononuclear or so fragmented as to be difficult of diagnosis. This process affects arteries as well as the veins, and the

infiltration extends throughout all the coats. The adventitial lymphatic sheath is in most cases distended and may contain masses of polynuclear and mononuclear cells with red corpuscles. Very often, however, this sheath contains only red corpuscles, but these in such numbers as to distend it to a diameter far greater than that of the blood-vessel. It seems most probable that this haemorrhage has occurred by diapedesis, constituting one of the evidences of inflammation, but here and there there are apparently evidences of the direct rupture of the wall of a small vessel. The distended lymph sheath may also rupture; at any rate, in nearly every case there is a zone of haemorrhage in the tissues around about it. Such extravasated red blood-corpuscles, like those within the sheath and the blood-vessel, are in a good state of preservation, indicating the extreme acuteness of the process. There is nowhere any definite accumulation of haematoidin or haemosiderin to be found in the tissues or in the lymphatics—further evidence of the rapid course of the disease.

The small vessels lying in the centre of such haemorrhages are very commonly such as are plugged with the rather blue-staining hyaline masses already described (Plate I, Fig. 2). Other vessels may contain a similar hyaline material and indeed hyaline is often found both within and surrounding the vessel. Especially is this true in the case of some of the larger vessels lying within those meningeal processes which pass deep into the sulci. There the surrounding tissue is spread apart by the presence of this coagulated material.

The nature of the hyaline substance offers perhaps some difficulty of explanation. Leyden and Goldscheider[1] express themselves as follows:

> Sometimes in oedema, softening or acute inflammation of the cord one finds in sections structureless amorphous masses. These occur in the central canal, in the grey substance, less often in the white matter, often about the vessels. This phenomenon is explained in various ways: by some thought to be coagulated albuminous or fibrinous exudate, by others interpreted as a colloid, hyaline, mucoid or gelatinous degeneration of softened nerve substance or swollen and diseased neuroglia. It is this structureless mass which Lockhart Clarke described as "granular or fluid disintegration." According to that author it consists in a softening and destruction of the nerve tissue and its change into a granular mass which, with the exuded fluid, mixes to form a homogeneous substance. These masses take the carmine stain very weakly. Their nature is not yet settled; it is even questionable whether the material under discussion is everywhere the same. The perivascular masses are most probably exudate: whether this will hold for all similar forms is, however, uncertain. The attempts to determine the nature of the substances by various stains have so far not been successful.

The problem before us is somewhat similar. The hyaline material within and about the meningeal vessels looks at times as if it had been produced by the coalescence of red corpuscles, but in general it is too abundant and homogeneous to be explained. It is rather denser and more refractive than coagulated plasma would appear, and with water

1 Die Erkrankungen des Rückenmarks und der Medulla oblongata, in Nothnagle's Spec. Path. u. Therap. Bd. X, Wien, 1897.

blue it stains brilliantly. In its general appearance and reaction it agrees fairly well with the larger hyaline masses in the areas of necrosis. Such hyaline material occurs also scattered about among the tissue elements, but nearly always about a vessel except in the most degenerated areas where the tissue becomes necrotic and entirely gives place to the structureless mass. There is even difficulty at times in outlining this necrotic substance from the hyaline material. Highly refractive as elsewhere it shows here, too, the tendency to contract and leave vacuoles, probably as the effect of the hardening reagent, so that the great central mass has, as a rule, an appearance almost like the cut surface of a Gruyère cheese (Plate I, Fig. 3). Often in such vacuoles a delicate coagulum can be made out, suggesting the presence there of a fluid of less density. The highly refractive substance is somewhat denser about the vacuoles. It is apparently very brittle in the sections and shows cracks and fissures here and there. It stains with eosin, taking a fairly bright pink color; Congo red tinges it brick red. Van Gieson's stain leaves it pinkish yellow—neither definitely red nor definitely yellow—with water blue and fuchsin it stands out sharply from the adjacent substance by its bright deep blue color; so also do the masses in and about the vessels. With Mallory's phosphotungstic acid haematoxylin it stains a rather pale, purplish pink; with his modified stain for connective tissue as applied to the nervous system, it takes a dense, deep purple color. With methylene blue, carbol fuchsin, Weigert's fibrin stain, etc., it is hardly tinged at all. Osmic acid does not stain it; in a Marchi preparation it is just visible as a smoky area.

The material stains therefore with acid dyes, in which respect (according to the hypothesis of P. Ernst) it corresponds to that form of hyaline derived from epithelial cells. Nervous elements being of epiblastic origin, might perhaps furnish the great mass of hyaline in the centre of the focus. There would be difficulty, however, in thus explaining the presence of a substance staining in exactly the same way in and about the arteries as well as the veins, and we must probably consider this one of the exceptions to the rule, as is the colloid of the thyroid which, although derived from epithelium, stains red with Van Gieson's stain.

In the smaller vessels in the neighborhood of the most intense degenerations the hyaline masses described above stain rather bluish with the haematoxylin and eosin stain, which seems to indicate that they are not quite identical in nature with the remaining hyaline substances described.

As stated above, the central hyaline mass in each focus is bounded by ragged edges of necrotic substance with here and there free islands of such tissue. Nowhere are there any evidences of the least pressure on this tissue, which becomes gradually rarefied toward the margin where it quite disappears. This mass is, therefore, in all probability the result of the breaking down of the brain substance—perhaps added to also by exudation of fluid from the vessels.

The exudation of leucocytes is not very abundant in the sections. Beside the infiltration of the walls of the small vessels and the tissue surrounding them, leucocytes are found sprinkled in considerable numbers through the most degenerated tissue in the focus where it borders upon the hyaline material. These leucocytes are easily distinguished by their sharp staining from the greyish purple degenerated neuroglia nuclei which persist there.

Besides the leucocytes there are a few somewhat larger round cells with small single round nuclei and granular protoplasm. These appear to be analogous to the fat granule cells which are so common in inflammatory diseases of the nervous system of longer standing, they are however rather scarce, and although in a Marchi preparation they can be made out to contain blackened fat droplets, they are by no means a prominent feature in the section.

The process is therefore predominantly a destructive rather than an exudative one. To resume, we have an acute disease, rapidly fatal, producing large areas of complete destruction of the brain substance in which the anatomical elements are disintegrated and largely replaced by a colloid-like material. In the neighborhood the blood-vessels are acutely inflamed, there is exudation of leucocytes into the vessel walls, and throughout the adjacent tissue, with passage of the red corpuscles into the perivascular lymph sheath and into the adjacent tissues, these focal extravasations giving the inflammatory process its haemorrhagic character.

The various forms of acute haemorrhagic encephalitis in man as described by Wernicke, Strümpell, Friedmann and others seem, as a rule, to progress less rapidly and to be much less violently destructive than this form. Anatomically, however, the conditions are analogous.

In horses the disease is apparently fairly well recognized. Friedberger and Frohner,[2] giving the bibliography, summarize the results of investigation into the pathology of acute encephalitis about as follows:

Local non-purulent encephalitis occurs in irregular, round foci, mostly of the size of a pea to that of a hen's egg, sometimes even involving a whole lobe of the brain, but not sharply limited. At first the place is slightly diffusely reddened, this being soon followed by a swelling and softening from serious exudation, when, according to Schütz, the cells of the neuroglia and the ganglion cells are swollen and granular, and finally undergo fatty degeneration; the axis cylinders are varicose and the glia tissue infiltrated with the small cells. The focus undergoes maceration, swelling and liquefaction, resulting finally in a softened mass consisting of disintegrated and fatty glia and ganglion cells, leucocytes and free fat-globular cells, and is spoken of as simple inflammation of the brain or inflammatory softening of the brain, distinguishable from ischaemic encephalomalacia by the exudation of leucocytes. This may be all, but often there are complicating haemorrhages giving rise to haemorrhagic inflammation of the brain. With the decomposition of the haemoglobin in such a focus the color disappears gradually and becomes yellowish. Then as the mass of disintegrated tissue

2 Lehrb. d. Spec. Path. u. Therap. d. Hausthiere, Bd. ii, p. 79, 2te Anfl., Stuttgart, 1889.

and exudate becomes more fluid, there is formed either a grey gelatinous mass or cyst, or finally a scar arises.

This description would apply to the cases described above fairly well except that the gelatinous fluid mass appears only at the end where the process is on the way to healing, whereas in our cases the brain substance throughout a large focus is quickly reduced to a gelatinous, structureless mass of necrotic and hyaline material.

The single case of our series in which recovery from the disease had occurred showed in the frontal lobe of one hemisphere a depression which on section of the brain corresponded with an elongated, grey, translucent scar which ran deep into the substance of the brain. This microscopically showed only a loose granulation tissue with numerous cells resembling the fat granule cells. Of course, whether or not it was really the end product of such a condition as described above depends on the accuracy of the diagnosis, but as the symptoms are fairly characteristic and the scarred condition of the brain about what might be expected as the final result of the anatomical process, it seems probable that this was an instance of recovery from the affection here described.

Addendum.—Since the above was sent to press there has occurred another outbreak of the disease in Southern Maryland in the course of which great numbers of horses have died. We were able to make three autopsies on animals in which the symptoms during life were such as were described above. The two horses when seen were comatose while the third animal—a mule—had died after a short but violent delirium. As the horses were obviously dying they were killed, but the autopsies revealed no recognizable macroscopic lesion. Microscopically, however, the vessels in the substance of the brain show in many places an acute inflammatory affection of and around the walls, and here and there in their neighborhood there is infiltration of the tissue with mononuclear polymorphonuclear and eosinophilic leucocytes. No widespread destruction such as that described for the previous cases was found in these cases, and it is clear that they represent an earlier stage of the affection than that described above.

Bacteriological examination in these cases led also to no satisfactory results. Cultures from the organs of the horses were sterile except for occasional obvious contaminations. A rabbit inoculated with an emulsion of the brain substance of the mule, which had been dead 48 hours, died with a general infection with a bacillus probably of the hog-cholera group and very virulent to rabbits. Further study of this organism will be made but it is not likely that it has any relation to the disease in question.

DESCRIPTION OF PLATES I, II AND III.

PLATE I.

Fig. 1. Photograph of a section through part of a focus of encephalitis showing the disintegration of the white matter, and the central hyaline substance.

Fig. 2. Small vessel with extravasation of blood into its lymph sheath. The vessel is partly filled with a hyaline material.

Fig. 3. Central portion of a large focus, showing the margin of the necrotic material and the central hyaline substance with vacuoles.

PLATE II.

Fig. 4. Small vessel with cellular infiltration of the wall, the perivascular lymph sheath being distended with blood.

Fig. 5. Nerve fibres undergoing degeneration. The myelin sheath forms droplets or varicosities along the axis cylinder. Other highly refractive droplets are scattered about in the tissue.

PLATE III.

Fig. 6. Ganglion cells which are losing their processes and becoming rounded—steps toward their complete disintegration.

Fig. 7. Photograph of a section of the brain, showing the entire area of disintegration. Such a well-marked case is rarely seen.

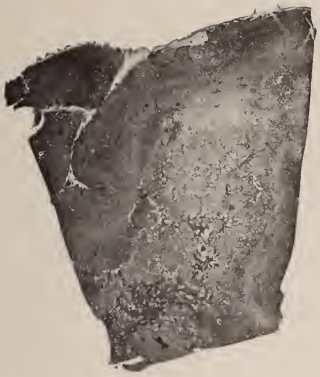


FIG. 1.

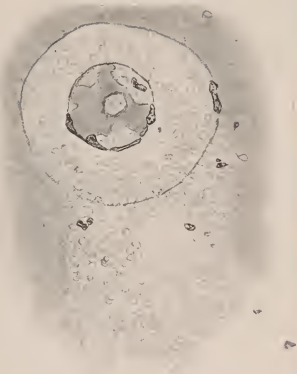


FIG. 2.

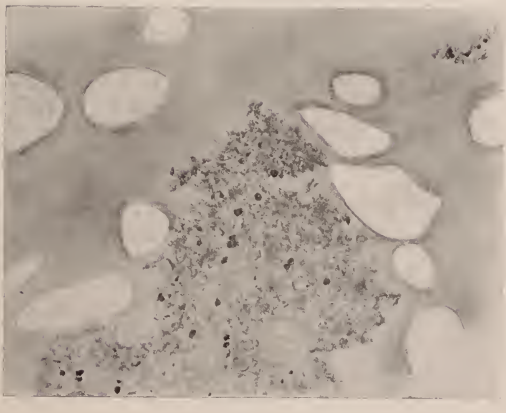


FIG. 3.

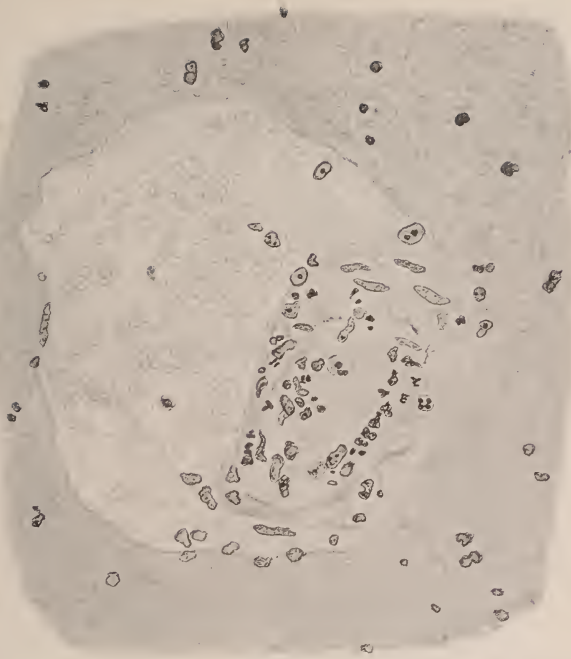


FIG. 4.

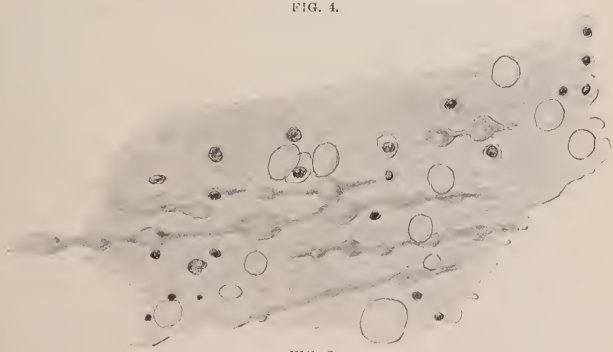


FIG. 5.

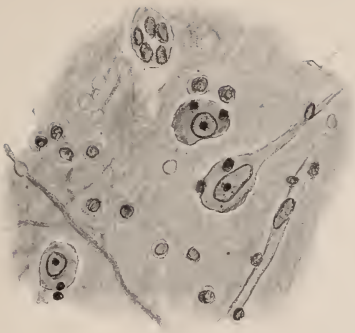


FIG. 6.

FIG. 7.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 81. FEBRUARY, 1902.

SOILS AND FERTILIZERS FOR GREEN HOUSE CROPS.

By H. J. Patterson and Thos. H. White.

INTRODUCTION.

The time has been when the gardener under glass threw over many of his operations more or less mystery; particularly was this true with regard to the soil preparations which were used and the methods of fertilization followed. But with the extension of this industry the secrets have not been so carefully guarded and what was once seemingly mystery is now seen to be quite simple. The soil preparations now commonly recognized as thoroughly satisfactory for nearly all classes of green house crops consists of making a compost of good old pasture sods with cow, horse and sheep manure. The texture or mechanical condition of the soils are varied through the addition of sand or clay and using varying proportions of cow or horse manure so as to make a soil which will meet the requirements of different classes of plants.

For fertilization stable manure has been the chief reliance, and in most all cases has furnished all that could be desired.

This system which is so simple and which gives such satisfactory returns would meet all the requirements of the culturist under glass, provided that a sufficient supply could always be had within easy reach. Unfortunately, the location and surroundings of most green houses are such that the old sods are consumed within a few years and the supply of the proper kind of stable manures is limited. There is no doubt but there is need of much more study upon the character of the soils and fertilizers which are adapted to various classes of plants and even to different varieties of the same plant. For instance, the wide variation in the results which are being obtained with the same varieties of carnations are no doubt in a large measure due to the character of soils and manures being used by different growers.

With the idea of throwing some light on this subject; particularly of trying to help those who cannot procure a supply of old sods and cow manure easily and economically a few experiments were undertaken and the results recorded in the following pages.

It is to be regretted that these experiments are not more thorough and that they do not cover a wider range of conditions and

possibilities. But this work could only be done on a limited scale and at times and upon space which was not needed for other work. Then, too, our green house facilities at best are rather limited.

The experiments treated in this bulletin will be discussed under the following heads:

1.—Soil preparation.

2.—Methods of using stable manure.

3.—The use of street sweepings in the green house.

4.—Methods of transplanting lettuce as effecting the use of fertilizers.

5.—Feeding chrysanthemums with fertilizers in solution.

6.—Commercial fertilizers on lettuce.

1. Soil Preparations.

As has already been stated soils which are the result of composting or decomposing old sods meets almost every requirement of green house crops and when this class of soil can be had in an abundance it leaves little if anything else to be desired. But as there are many who find it impossible to obtain sufficient sod for composting and with a view of aiding this class in their search for a satisfactory substitute for the sod the following experiments were undertaken. These tests, though not conclusive, yet may be of some help and the results are in the nature of a report of progress.

In general agriculture and with truck crops in the field it has been found that the use of green manures can, in a large measure, be made to act as a substitute for sods in bringing up and maintaining a proper amount of organic matter in the soil and thus a good physical condition. Now, why may not the soils for green house crops be prepared by using green crops as a source of organic matter and plant food or as a substitute for old sods? If green crops, such as crimson clover, cow peas, &c., can be used as a substitute for sod it is very certain that many who now have much difficulty in obtaining sod could easily grow a green crop for the purposes of composting to furnish the green house soil.

The plant used in this test was lettuce as the balance of the house was being devoted to this crop. The following are the different soil preparations which were tested:

Section No. Season 1898-99.

1. Heavy Clay loam 4 parts by measure thoroughly mixed with 2 parts by measure of well rotted manure. This soil preparation was six inches deep on bench.
2. Heavy clay loam (same as No. 1) without any manure mixed with it placed 4 inches deep on bench over a layer of the well rotted manure 2 inches thick.
3. Same as No. 1 with light loam base.
4. Same as No 2 with light loam base or same soil used in No. 3.

5. Same as No 1 with compost of upper six inches of soil and sod from old lawn as the base.
6. Same as No. 2 with same old sod compost as used in No. 5 over the layer of manure.
7. Equal parts of Branch sand and light loam (such as used in sections 3 and 4) well mixed with manure.

Lettuce plants were set out on these sections on December 30, 1898—the plants being uniform as to variety, size, &c. The heads were matured and cut February 25th, 1899.

Results.—The plants all grew off nicely and made a very good growth giving lettuce that headed up well and of fine quality. There was no difference which could be noted between the plots having the manure mixed with the soil and those having it as a layer under the soil.

The best lettuce, finest in quality and heaviest yields were produced on Sections 1 and 2, second best on Sections 5 and 6.

These tests were repeated during the same winter with another crop of lettuce and the same results were obtained.

Season 1899-1900.

The soils prepared for the season of 1899 and 1900 were made by composting according to the following:

Compost No.

1. Light loam with crimson clover 3 parts plus 1 part particularly rotted hog pen manure.
2. Light loam with crimson clover 3 parts plus 1 part well rotted barnyard manure, (mixed cow and horse).
3. Heavy wheat land soil (clay loam) with timothy sod 3 parts plus 1 part particularly rotted hog pen manure.
4. Heavy loam with crimson clover 3 parts plus 1 part well rotted barnyard manure.
5. Light loam 3 parts plus 1 part fresh horse manure.
6. Light loam 3 part plus 1 part of fresh cow manure.

The soils for these composts were collected and the composts prepared on May 26, 1899. The soil was in nice condition for working and handling at the time of making the compost. The composts were made up of alternate layers of the soil and manure. After the piles were made up they were covered with straw manure so as to preserve the moisture. In this connection of preserving the moisture in soils for green houses it may be well to remind growers that our observation and experience has shown that where soils have been allowed to become powdery dry the disease which attacks lettuce are more prevalent; particularly the rot on the heart about the time it begins to head. The Massachusetts Hatch Experiment Station in Bulletin No. 69, states that the lettuce "Drop" is accelerated in soils which have been allowed to dry out. No doubt that many other

plant diseases may be more prevalent or pronounced under similar circumstances. It was to avoid these troubles that the composts were covered to preserve moisture.

The composts were worked over several times during the summer. On August 11th, each pile was divided into to equal parts. One part was used in the soil experiment, the other part was supplemented by chemical fertilizers and used in fertilizer tests which will be treated of later.

The soil was put into the houses on September 18th and planted to lettuce. The different sections of the bench were separated by division boards. The lettuce used was of the "Boston Market" variety. The seed was planted August 17th. Special care was exercised to have the plants uniform in size and character.

The weather was unusually warm the latter part of October which made the lettuce show a tendency to run to seed without forming good heads. On this account the crop was cut October 23rd. The yields are given in Table I.

As soon as this crop was removed the soil was spaded over and again planted to "Boston Market" lettuce the seed for this crop was planted in a cold frame October 5th. This second crop was cut and weighed January 1st, 1901. The results were as follows:

TABLE I.

Yield of Lettuce with Different Soil Preparations—Season 1899-1900.

Plot and Soil No.	Crop cut Oct. 23. Weight oz.	Crop cut Jan. 1. Weight oz.	Total 2 Crops. Weight oz.
1	30	36	66
2	33	27	60
3	39	45	84
4	42	49	91
5	33	22	55
6	28	48	76

From the results obtained above it will be noted that the heavy loam with the crimson clover gave the best results. From which it would appear that such green crops as crimson clover could be used to advantage where sod is not available. The results of both years' work seems to favor the heavier soils for lettuce.

2. Methods for Using Stable Manure.

All gardeners recognize the value of stable manure and would in most cases feel satisfied to place their entire dependence upon it as a source of fertilization. Even with this universally recognized value; yet there is found a great diversity of opinion as to the best or proper method of its application and use. The tests made with stable manure cover the following points:

1. Comparing thoroughly mixing the stable manure and the soil with putting the same quantity of manure as a layer on the bottom of the bench under the soil.
   (A) Using heavy clay loam soil.
   (B) Using a light sandy loam soil.
   (C) Using a composted old lawn sod soil.
2. Comparing a thoroughly rotted manure with a fresh manure applied as a layer on top the soil.
3. Comparing hog pen manure with mixed cow and horse manure for composting with soils.
   (A) Using light loam soil base.
   (B) Using heavy clay soil base.
4. Comparing horse manure and cow manure for lettuce with light loam soil base.

1. Lettuce was the crop used in the comparison of the use of stable manure mixed with the soil and placing the manure as a layer on the bottom of the bench under the soil. The manure used was well rotted.

The results of all the tests made gave no difference in the two methods of application. With soils of less fertility and different mechanical condition the admixture of the manure with soil might exert a different influence and there also might be a different preference manifested by other crops.

2. In the use of well rotted and fresh manure there seems to be considerable variance of opinion, which no doubt is largely due to the kind of crop grown and local conditions.

It is not infrequent to hear gardeners state that manure which has been used for hot beds and undergone thorough fermentation in this use has lost all of its virtue and is worthless. Again, others contend that such manures or manure which has thoroughly rotted must be had notwithstanding the loss of plant food incurred because of this excessive fermentation. During the winter of 1900 tests were made with this well rotted manure in comparison with some manure taken directly from the yard, which was not exactly fresh yet in a wet soggy condition and it had shown no signs of fermentation.

This experiment was conducted on the solid beds and had grown a crop of chrysanthemums just previous. As soon as the chrysanthemums had been removed the bed was prepared by thorough spading and raking. The manure was applied as a top dressing; putting it on to the depth of one inch. The bed was divided into two equal parts separated by a division board set into the ground. One half received the well rotted manure and the other the unfermented manure. The plants were set so as to have their roots in the soil and not to come in too close contact with the manure. ("Rawson's Crimpled Leaf" was the variety used).

Results.—The lettuce planted on the plot top dressed with the well rotted manure took hold and started to growing promptly and vigorously; while the others started slowly. Plate No. 1. shows

Plate 1.—Left—Fresh manure. Right—Well rotted manure.

these plots at the end of 72 days. It will be noted that the plat on the left which received the rotted manure is mature and part of the lettuce has been cut. The other plot was ten (10) days later in maturing its crop. There was no difference in the total weights of the crops from the two plots yet when the fact is considered that the rotted manure had the effect of hastening the maturity ten days, it was of considerable advantage to the grower.

3. The manner of preparing the composts for the comparison of hog pen and mixed stable manure, see page 79 of this bulletin.

The results of this test are already given in Table I. page 80, see plots 1, 2, 3 and 4.

From these figures it would seem that hog pen manure gave a slightly higher average results than the mixed manure; but when the soil base is taken into consideration we see that hog pen manure did best with the light soil and that the mixed manure did best with the heavy soil. From these facts it would seem that the results were largely dependent upon the physical changes produced rather than the plant food furnished. Reasoning upon this phase, the results are as would be expected, that is, the hog pen manure would be most beneficial in making the soil heavier in its characteristics and the mixed horse manure would be best for lightening up a stiff soil.

4. For manner of making the composts of horse and cow manure, page 79. The results of the comparison of these two manure are given in Table I. page 80, see plots 5 and 6

The results seem decidedly in favor of the use of cow manure.

3. The Use of Street Sweepings in the Green House.

Street sweepings have attracted very little attention from the growers of crops under glass and there has been but little of this material used for green house crops.

The results which have been obtained at this place with the use of composted street sweepings in various ways have certainly been quite satisfactory and would make this source of vegetable matter and fertility worthy of the serious consideration of all florist and glass house culturists.

While street sweepings contain a fair amount of plant foods; yet its chief value (from the results and observations which have been obtained here) would seem to rest in the mechanical effects which it produces.

A mulch of 1 to 2 inches of well rotted street sweepings placed over the beds in which lettuce was planted, and the lettuce plants set so their roots were in the soil below, prevented the "damping off" to which lettuce is often subject and which was quite prevalent on plots which did not have the street sweepings mulch.

Not only did the street sweepings mulch seem to prevent the "damping off" but the crops made a fine growth and kept the under leaves of the plants in a nicer condition than when they lay on the

soil which holds moisture and produces more or less discolorations and sometimes rot.

Tests have been made by using well rotted street sweepings in a variety of ways for potted plants. The results have in all cases been very satisfactory. In the "growing on" of young stock the street sweepings have proven to be distinctly valuable. Coleus potted from the sand into two-thirds of the street sweepings and one-third loam made an exceedingly rapid, healthy and vigorous growth. Two-thirds sweepings and one-third sand have been used with some classes of plants with good results.

Some very fine growths have been obtained by the potting of plants into pure well rotted street sweepings. This pure material while giving good results yet dries out rather rapidly. At the same time no bad results would attend excessive watering when potted into pure well rotted street sweepings.

The street sweepings make an excellent plunging medium for all classes of stock in the house and for rubbers, (Ficus elastica) palms, etc., when out doors in the summer.

The street sweepings made a good substitute for spent hops and it may possibly serve the place of the cocoa fibre so largely used in Europe by the florists. The well rotted street sweepings will be found very helpful as a substitute for "leaf or woods mold" which is now difficult and expensive to obtain.

Plate 2 shows some Cyclamen (Fig. 1) and Rex Begonias (Fig. 2) which were grown in well rotted street sweepings alone. Plate 3 shows some Lantanas grown with three kinds of potting material, as follows:

Row 1. Compost of sod 3 parts and manure 1 part. This material 3 parts and, 1 part sand.
Row. 2. Two-thirds leaf mold one-third sand.
Row 3. Two-thirds street sweepings one-third sand.

The Fertilizing Value of Street Sweepings.

The fertilizing value of street sweepings varies greatly with the nature of the pavements. It is very little or practically nothing in the case of material which would come from macadamized roads but is very nearly as rich as stable manure when obtained by sweeping and hand collections from the well paved streets of large cities.

The following table gives the amount of plant foods which was found in street sweepings used at this place together with the analysis of some other materials which might be of interest in this connection.

Fig. 1.—Cyclamen. **Plate 2.—Showing plants growing** in well rotted street sweepings. Fig. 2.—Rex Regenia.

Plate 3.—Lantannas growing in three kinds of potting material. Row 1.—Composted sod 9 parts, manure 3 parts and sand 4 parts. Row 2.—Leaf mold 2 parts and sand 1 part. Row 3.—Street sweepings 2 parts and sand 1 part.

TABLE II.

Comparison of Street Sweepings with Some Other Materials for Comparison Per Cents.

	Water.	Mineral Matter.	Nitrogen.	Potash.	Phosphoric Acid.
Street Sweepings (Fresh)	26.56	57.59	0.51	0.06	0.27
Street Sweepings (Well Rotted)		36.40	0.53	0.42	0.32
Horse Manure (Fresh).....	48.69		0.43	0.44	0.29
Cow Manure (Fresh)[1].....	75.00	5.15	0.57	0.20	0.31
Spent Hops			1.08	0.40	0.31
Cocoa Fibre					
Oak Leaves			1.00	0.35	0.20
Jadoo Fibre[2]			0.76	0.21	0.56

Purchased in Washington, D. C. Samples represent carload.

1. Samples from steers fed in concreted pits where all the liquid excrements were absorbed by the bedding—analysis by H J. Patterson.

2. Peat moss soaked in a solution of fertilizing materials.

4. The Effects of Commercial Fertilizers on the Method of Transplanting Lettuce.

In connection with the use of commercial fertilizers on greenhouse crops some tests were made with different methods of transplanting lettuce. The tests were conducted with the following ways:

1. Young plants pricked from seed bed and transplanted to 2½ inch pots containing good soil.

2. Young plants pricked from seed bed and transplanted to benches with soil two inches deep. Plants set two inches apart.

3. Plants left in seed-bed until transplanted to green-house.

The plants were set on February 27th and cut April 8th. The fertilizers used were thoroughly incorporated with the soil.

The following table gives the quantity of fertilizer applied to each plot and the yields per plot.

TABLE III.

Quantity of Fertilizer Applied and Yield of Sections of Plots With Different Methods of Transplanting.
(Fifteen Plants to Each Section.)

Plot No.	Quantity of Fertilizer.	Potted Plants.		Paints Transplanted to Bench.		Plants drawn from seed bed.		Total Yield.
		Yield.	Weight per head.	Yield.	Weight per head.	Yield.	Weight per head.	
		lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs
1	500 lbs.	4.8	3.2	3.4	2.3	1.3	0.9	9.5
2	1000 lbs.	4.2	2.8	3.6	2.4	2.2	1.5	10.0
3	1500 lbs.	4.6	3.1	4.2	2.8	1.7	1.1	10.5
4	2000 lbs.	4.2	2.8	3.8	2.6	2.0	1.3	10.0
5	Nothing	4.5	3.0	5.0	3.3	3.2	2.1	12.7
	Total	22.3		20.0		10.4		

A study of these figures in Table III shows not only the decided advantage from transplanting to pots, but also that such plants have the ability to withstand the injury which may be produced by the tender roots of young plants coming in contact with concentrateed solutions of fertilizing matter. One transplanting on the bench before setting in the bed was also productive of much benefit, as this permitted the carrying of a small lump of earth around the roots.

The fertilizer applied in the above test was made up as follows:

Dissolved South Carolina rock	500 lbs.
Dried Fish	600 lbs.
Nitrate of Soda	300 lbs.
Carbonate of Potash and Magnesia	400 lbs.
High-Grade Sulphate of Potash	200 lbs.
Total	2,000

This formula would analyze approximately the following:

Phosphoric Acid	6 per ct.
Potash (K_2O)	8½ per ct.
Nitrogen	4½ per ct.

Why the application of such a fertilizer should have given negative results is hard to understand or explain, but the results discussed hereafter may throw some light on the situation.

The soil used was a light loam, which had been well enriched by an application of well rotted stable manure previous to the application of the chemicals. The results would seem to indicate that the supplementing of the yard manure with chemicals was not necessary, and really gave the plants not only more than they could use, but more

than was good for them. There is probably a sort of indigestion among plants, the same as animals, and under some circumstances it is probably much better to feed a little and often rather than make heavy applications at one time.

5. Feeding Chrysanthemums With Fertilizers in Solution.

In this work the object was to compare the use of some chemical solutions with the cow manure water, which is in general use by florists. Previous experience and observations seemed to indicate that feeding with the cow manure solutions developed very fine stem and foliage, but somewhat at the expense of the flower. In this connection it was thought that probably this resulted from an insufficient amount of phosphoric acid. The tests which follow were planned with the object of throwing some light upon this point.

Season of 1899.

For this year's work the south half of the green-house was selected. It was divided into six sections, which were separated from one another by boards so as to allow a small unoccupied space between each section. The soil used was prepared early in the summer by composting one-quarter cow manure with three-quarters of a rather stiff loam. Ivory was the variety selected for use in this test. The plants were carefully selected, so as to have them as uniform as possible, and all were trained to a single stem. The fertilizers were mixed and dissolved in barrels of water. The following formulae were used:

Formula 1.
Used on Sections 1 & 2. Fresh cow manure 100 lbs. +Water 50 gal.

Formula 2.
Used on Section 3.
- Slag phosphate 3.2 lbs.
- Wood ashes 8 lbs.
- Nitrate of sodal
- Sulphate of ammonial

+Water 50 gal.

Formula 3.
Used on Section 4.
- Double superphosphate 0.4 lbs.
- Nitrate of potash, 0.9 lbs.
- Sulphate of ammonia 1.0 lbs.

+Water 50 gal.

Formula 4.
Used on Section 5.
- Sulphate of ammonia 1.0 lbs.
- Nitrate of soda 1.0 lbs.
- Wood ashes 8.0 lbs.
- Slag phosphate 0.7 lbs.

+Water 50 gal.

Section 6—No fertilizer.

Sections 1 and 2 of the bench were watered with formula 1, or cow manure. Section 3 was watered with formula 2; Section 4 with formula 3; Section 5 with formula 4, and Section 6 was watered with

clear water only. The watering with these fertilizing solutions commenced as soon as the buds had formed, and repeated twice a week until the buds commenced to burst and show color.

These formulae were made up so as to have No. 3 analysis approximately the same as the cow manure, while No. 2 had more of phosphoric acid and No. 4 less.

Results.—The results obtained showed no benefit from the use of the cow manure, as the bloom foliage and stem were no better than those on Section 6, receiving no fertilizing solutions.

The sections watered with the chemical solutions showed marked results in the superiority of the deep green color of the foliage size and stiffness of the stem. The bloom was also slightly larger and a little earlier. Sections 3 and 5 were about the same, and somewhat better than Section 4.

This would seem to indicate that the phosphoric acid was a necessary and valuable addition, but yet gave nothing conclusive on this point.

Season 1900.

As the cow manure (excrement) made such a poor showing in the experiments conducted in 1899, it was determined to test if the cow urine would not be more effective, or, in other words, if it was not this urine, rather than the dung, which was of value for watering flowers.

For this year's work the same bench was selected and divided as in previous years. The soil used was collected from a strawberry patch that had been plowed a month or so previous. It had no manure composted with it. The soil was a strong, rather stiff, loam. The solutions used were made up as follows:

Plot No. 1.—Diluted cow urine from tank which received the urine, and washings from the stable. This showed an analysis of 0.05 per cent. nitrogen.

Plot No. 2.—Twenty-five gallons same dilute urine as used in No. 1 + 1 pound dissolved South Carolina rock.

No. 3 { Dissolved S. C. Rock.... .....1 lb.
Sulphate of Ammonia.... .....8 oz.
Muriate of Potash..... .....1½ oz. } +25 gal. water.

No. 4 { Dissolved S. C. Rock .....1 lb.
Nitrate of Soda.....6 oz.
Muriate of Potash .....1½ oz. } +25 gal. of water.

No. 5—Nothing.

The variety of chrysanthemums used in the test this year was Major Bonaffon. The watering was done as in previous year's work.

The effects of the applications this year was much more marked than in the previous year; presumably on account of the soil not having any manure composted with it.

Plate 4.—Showing average chrysanthemums grown with different fertilizing solutions, season 1900, see page 90

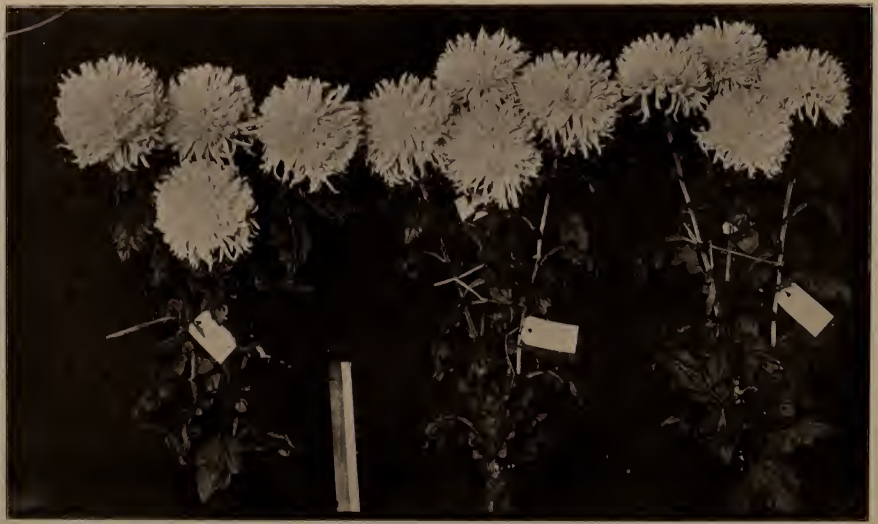


Plate 5.—Showing average chrysanthemums grown with different fertilizing solutions, season of 1901, see page 93.

Results.—The following results were noted. All of the plots were very fine. Plot No. 2, which received the urine solution, supplemented with the dissolved S. C. rock, gave the best specimens. Plot No. 4 was a very close second. A photograph of average specimens from the different plots is shown on Plate 4 (taken November 23rd). This year's results would seem to support the idea that phosphoric acid was valuable in the full development of the flower.

Season 1900 (Solid Bed).

Some fertilizer experiments were made on chrysanthemums with different forms of phosphoric acid when applied in the solid form to the soil.

The solid bed in the centre of the house was devoted to this test. The soil in this bed was placed in the house in 1898. It had been manured each season with well-rotted barnyard manure, and cropped continuously in a succession of crops, 1st chrysanthemums, 2nd lettuce, 3rd radishes, 4th beets and 5th cucumbers.

The bed was divided into four parts, which were separated from one another by board partitions set down into the ground. The following applications of fertilizers were made:

Plot 1—Raw bone meal, at the rate of 600 lbs. per acre.

Plot 2—Dissolved S. C. rock, at the rate of 600 lbs. per acre.

Plot 3—Slag phosphate, at the rate of 600 lbs. per acre.

Plot 4—Nothing.

The results were slightly in favor of the bone meal, as this produced a longer stem and richer foliage. This was, no doubt, due to the nitrogen or ammonia contained in the bone meal.

The dissolved S. C. rock stood second. The slag phosphate produced no noticeable effect, as the foliage and bloom on this plot were no better than on the plot receiving nothing.

Season 1901.

The tests in 1901 were conducted on the same bench as previous seasons. The soil used was prepared by composting some sod with the upper three inches of soil from an old pasture. This compost was started in the spring, and was worked over several times during the summer. Ivory was the variety used in this year's test. The feeding was conducted as usual by starting as soon as the buds formed, and continuing twice a week until the flowers were considerably advanced. The following were the treatments given the different plots:

No. 1—Nothing.

No. 2—Sixteen gallons pure cow mnure, allowed to stand for ten days to ferment, and then diluted with water to forty-eight gallons.

No. 3—Nitrate of soda, 3 lbs., 8 oz.; Muriate of potash, 1 lb., 3 oz. +48 gallons water.

Plate 5 shows a photograph of average bloom from each plot. Some growers may fail to recognize "Ivory" in this plate on account

of the twisted petals. This condition can probably be accounted for by the long-continuel spell of bright hot days, as the "Ivory's" on the north bench, which were somewhat shaded, continued normal and finished well.

It will be noticed from this picture that the best bloom was from the nothing plot, No. 1, while the foliage was best on plots 2 and 3. This would seem to support the results obtained in previous seasons of the necessity of having a properly balanced fertilizer, and of the value of phosphoric acid in bloom development.

Season 1901 (Solid Bed).

The solid bed which was used for the phosphoric acid test in 1900 was used for another fertilizer test in 1901. The division boards were removed, and the bed divided into four parts, the division boards being placed at right angles to the way they were in 1900. The different plots were fertilized as follows:

	Slag phosphate	3.40 oz.
Plot 1	Dried blood	12.00 oz.
	Muriate of potash	2.60 oz.
	Dissolved S. C. Rock	2.66 oz.
Plot 2	Dried blood	12.00 oz.
	Muriate of Potash	2.60 oz.
	Bone Meal	2.88 oz.
Plot 3	Dried blood	11.56 oz.
	Muriate of Potash	2.60 oz.

Plot 4 Well-rotted barnyard manure, 50 lbs. per plot, or at the rate of 50 tons per acre.

The idea was to apply enough commercial fertilizer to the different plots, so as to supply as much plant food as was furnished by the stable manure on plot 4, but to make the application at several times rather than all at once. The above amounts of commercial fertilizers were applied before setting the plants. The application was repeated on August 29th, and again on October 3rd, with the exception that four ounces of nitrate of soda was substituted for the blood of the last (October) application.

Four varieties were planted on these plots, viz., Nivens, Ivory, Modesto and Glory of the Pacific.

In this test there seemed to be no difference in the effect of the different sources of phosphoric acid. All of the fertilizer plots gave better results than the stable manure. The bloom was better and the stems much stiffer with the short joints and vigorous, heavy, dark green foliage, so much desired by the commercial growers. This con-

dition can probably be largely attributed to the use of the dried blood as it has been noticed to have this effect in some pot experiments.

6. Tests of Some Commercial Fertilizers on Lettuce.

The result of the test of applying different quantities of commercial fertilizers are given in Table III. These are of little interest, as they all gave negative results, yet, are of value in pointing out lines for future work.

Season of 1899.

The following results were obtained as to the effects of some commercial fertilizers upon lettuce, which was planted on some plots just previously used for experiments in feeding chrysanthemums with fertilizers in solutions. As soon as the chrysanthemums were removed the plots were planted to lettuce. The lettuce received no fertilizer whatever, but the residue of the fertilizers which had accumulated in the soil showed marked results upon the lettuce. See pages..... for the formula used on the different sections.

When the crop matured it was found that Section 5 produced the finest lettuce; Section 4 produced second-best; Section 3 third best; Sections 1, 2 and 6 about the same.

Season of 1900.

As soon as the chrysanthemums were removed the plots were set to lettuce. No manure was applied to the lettuce, and the effects produced were due to the residues which had accumulated. (See p. p. for formula applied to plots.) The average weight per head of lettuce from the plots were as follows: Plot No. 1, 8 oz; plot No. 2, 9 oz.; plot N. 3, 5 oz.; plot No. 4, 6 oz.; plot No. 5, 4½ oz.

It will be noticed that the plot which gave the best chrysanthemums also gave the best lettuce; but that they did not follow the same order with the balance of the plots.

Fertilizers Applied to Cold Frame Lettuce.

Some cold frames were planted to lettuce the middle of March. The soil in these frames was a heavy clay loam, and was prepared by thoroughly chopping and spading in some well rotted manure, and it was in a nice fine condition when the plants were set. There were five sash set out. The sash were placed over the lettuce for a few days, but as they were needed for hot-beds they were taken off, and the frames covered with cheese cloth. The weather remained unusually cool, and the lettuce made very slow growth. On this account it was decided to try some commercial fertilizers put on as a top dressing, sowing it between the rows and working it into the soil with a small-pronged hand weeder. The fertilizers used were as follows:—the quantities mentioned indicate the rate per acre:

Sash 1	Dissolved bone black.....850 lbs. Nitrate of soda.....50 lbs. Dried Fish .....100 lbs.	Total, 1,000 lbs. per acre.
Sash 2	Dissolved S. C. Rock.....250 lbs. Nitrate of Soda.....150 lbs. Dried Fish .....300 lbs. Carbonate of Potash.....200 lbs. Sulphate of Potash.....100 lbs.	Total, 1,000 lbs. per acre.
Sash 3	Nitrate of Soda.....250 lbs. Dried Fish .....750 lbs.	Total, 1,000 lbs. per acre.
Sash 4	Dissolved S. C. Rock.....900 lbs. Nitrate of Soda.....100 lbs.	Total, 1,000 lbs. per acre.

Sash 5—No commercial fertilizer.

The following are the yields:

	Total Weight.		Average Weight per Head.
	lbs.	oz.	oz.
Sash No. 1—32 heads	17	14	8.9
Sash No. 2—32 heads	19	13	9.9
Sash No. 3—32 heads	22	00	11.0
Sash No. 4—32 heads	17	3	8.5
Sash No. 5—32 heads	17	0	8.5

From these results it is noted that the application to No. 3 produced a decided advantage in yield and size of head, and from the notes recorded it was also one week earlier in maturing. This can be attributed to the ammonia. Sash No. 2 was second in order of maturing, and sash No. 1 stood third.

The results obtained with this heavy application of commercial fertilizer was quite different from those recorded on page....; there is no doubt that this is in some measure due to difference in temperature in the two tests.

These points, as well as an extension of the work on fertilizers and soils for green-house crops, will be made the subject of future study on a much larger scale, and we trust if facilities are given to have future work more thorough in every way.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 82. MAY, 1902.

THINNING FRUITS.

E. P. SANDSTEN, Associate Horticulturist.

The object of this bulletin is to call the attention of the fruit-growers of Maryland to the value, if not the necessity, of thinning their fruit. The practice of thinning fruit has long been known to the fruit grower in Europe, and off years in fruit with them, is almost unknown. In America where the desire is to produce quantity rather than quality,—the practice is generally looked upon with disfavor. Of late years, however, the practice has been taken up by most of our successful fruit growers, and the consensus of opinion is that thinning pays well. The most successful grower now-a-days is not the one who raises the largest quantity of peaches or apples, but the one who produces the finest and highest quality of fruit. Superior fruit cannot be obtained from a tree that is overloaded with fruit. The capacity of a tree is limited, and it cannot be exceeded, no matter how many fruits may be set. If many fruits are set and are allowed to remain, the energies of the tree are spread out over the larger number, and few, if any, will reach the limit of their possible growth. If on the other hand, one-half or two-thirds of the young fruits are removed, the remaining ones will have an opportunity to develop to a normal size. Moreover the vitality of the tree is greatly preserved by such reduction, since it is not the size of the fruit that impairs the vitality of the tree, but the number of seeds, which are allowed to mature. By removing one-half or more of the young fruits, we do not only make it possible for the tree to produce a larger and finer fruit, but we also preserve the vigor and longevity of the tree. Judicious thinning makes it possible in many cases to produce a crop of fruit every year, and still keep the tree in better state of health. Thinning also tends to produce better colored fruit, as it permits the sun to reach many places, which would otherwise not be reached. It also permits a freer circulation of the air. Thinning will in a large measure lessen the heavy losses occasioned by rottening of the fruit. The fruit will be further apart and there will be little or no chance for the fruit to touch each other, making the danger of infection by contact with the disease or diseases more difficult. Thinning prevents the breaking down of the trees and tends to keep the shape of the trees in orchards more uniform.

When to Thin.

Peaches and plums should not be thinned before the "June drop" is over, and also the danger of depredation by the curculio is past. In the case of peaches, they should never be thinned to less than five inches apart. Six or eight inches is recommended when the finest quality of the fruit is desired. Plums should be thinned to about two or three inches apart. Apples should be thinned to about the same distance apart as peaches. Pears should be thinned about four or five inches apart. Apples and pears should be thinned when the fruit is about the size of a small crab apple.

The thinning is best done by the aid of a stout step ladder, having broad steps and platform. The trees may be thinned on the north side in the forenoon, and on the south side in the afternoon, so as to permit the person doing the thinning to be in the shade. To insure thoroughness in the work, each branch should be completed before the person starts to thin the next one.

One of the greatest objections to thinning is the seeming cost of the operation. This objection is more imaginary than real. If allowed to remain, the fruit would have to be picked in the fall, when labor is higher and the rush of work is greater. Besides the cost of removal of small fruit is much less than removing them after they are ripe. Another objection is that the total bulk will be less, if half or more than half of the fruit is taken off while young. Experiments have proven the contrary. All things being equal, the bulk will be equal, if not greater, if the fruit is properly thinned. The question of time is often a problem with some growers, but usually at that time of the year, labor is abundant. Little difficulty should be experienced on this score. Besides the work can easily and efficiently be done by women and children. In fact they are better adapted to this kind of work than are grown men. Another great obstacle to thinning is found in the fact that few people are willing to take off the young fruit. It seems to them an unnecessary waste. Sentimentality also plays a part with many people in preventing them from doing what they ought to do. The sentiment, however, should be all on the other side, for is it not better that a few fruits should come to perfection rather than all should suffer from the lack of sufficient nourishment?

The benefits to be derived from thinning fruits may be briefly summarized as follows:

First.—Thinning preserves the vitality of the tree by lessening the production of seed.

Second.—Thinning, if systematically and persistently done, will cause the tree to bear crops more regularly. Off years are in most cases due to the fact that the trees are allowed to overbear one year and during that year, few, if any, fruit buds can be formed. Most kind of fruit trees cannot produce a large crop and mature fruit buds at the same time.

Third.—Thinning lessens the loss occasioned by rot, and other fungus diseases of the fruit, by eliminating the danger of infection by contact. It also in a measure prevents the appearance and the spread of diseases by permitting better ventilation and drying of the fruit inside of the trees.

Fourth.—Thinning will produce larger fruit.

Fifth.—Thinning will produce a better colored fruit by admitting more sun-light into the tree.

Sixth.—Thinning tends to ripen up the fruit more uniformly.

Seventh.—Thinning will produce a more salable and higher-priced fruit by reason of the increase in size, higher color and general appearance.

Eighth.—Thinning will preserve the shape of the tree and prevents the breaking of overloaded branches.

Objections or Apparent Objections to Thinning.

First.—The apparent costliness of the operation. It seems to many an expense without any return.

Second.—Difficulty in obtaining help.

Third.—The seeming wastefulness of destroying something that the tree has produced.

It should be understood that thinning will not pay except the other practices, which go with proper fruit culture, have been attended to. It will not pay to thin an orchard which has not been properly pruned, sprayed, fertilized and cultivated.

THE MARYLAND

AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 83. MAY, 1902.

AN INQUIRY AS TO THE CAUSES OF PITHINESS IN CELERY.

By E. P. Sandsten and Thos. H. White.

This bulletin, on the probable causes of pithiness in celery and celery growing, is the result of a series of experiments which have been carried on for several years. The notes and other data contained herein were collected by Mr. Thomas White, the gardener of the horticultural department.

While it is not intended that this bulletin should be the final report on this subject, but merely a preliminary report of it, it was thought advisable to publish the results thus far obtained and lay them before the truck farmers of Maryland for their consideration. Arrangements have been made to carry on the work still further and to publish a final report, when it has been completed.

E. P. SANDSTEN, Associate Horticulturist.

History.

The fact that celery often grows pithy has long been observed by scientists and practical growers, and many causes have been ascribed for the same. Nicholson's Dictionary of Gardening says, "Medium sized stalks are generally more solid than very large ones, consequently they should be preferred, the latter being often hollow-stalked and useless for any purpose." Henderson's Hand Book of Plants says, "Although under ordinary conditions the proper varieties of celery are used, the crop should never be pithy or hollow; yet we have found that now and then even the most solid kinds of celery have become more or less hollow when planted in soft, low soils, such as reclaimed peat-lingo, where the soil is mostly composed of decayed vegetation."

"The name of the earliest varieties suggest that growers then considered the solidity of the stalk an important quality. There were the 'Red Solid, the White Solid, the Crystal White Solid, Late White Solid, Incomparable Dwarf Solid,' etc. It is now generally understood that all of the modern varieties have solid stalks normally. Nevertheless plants with pithy stalks occasionally occur in

all fields. Perhaps they are more common in some varieties than in others, although we do not know that any kind is entirely free from them. It is probable an hereditary trait, and, where there are generally many plants of this kind, it is generally inferred that the seed was from poor stock; still the condition of the soil may make some difference."

It is also generally believed by practical growers that pithiness is due to high temperature and lack of sufficient moisture, during the early stages of growth of the young seedlings after they have been planted in the field. The young plants during such weather become hard and dwarfed in their growth, and when the cool and moist weather in fall comes, they are unable to respond to the vigorous growth it engenders. Hence, there appear two distinct zones of growth—one composed of hard tissue, formed during hot dry weather in July and August; the other of soft and open tissue, formed during the cool and moist period of autumn. Undoubtedly, both soil and climate have much to do with the proper development and solidity of the celery plants, but not to such an extent as is generally supposed.

The seed used in these experiments was purchased from several of the leading seed firms in this country, and the plants were grown under the best possible condition to insure uniformity in result. The variety used the first year was Golden Self-Blanching. Three samples of seed were obtained, two of American grown and one of French grown. The seed was sown the 18th of March, 1890, and was given ordinary culture. Two hundred young plants of each kind were selected from the seed-bed and planted in the same bed in the open field, June 14th, and were given the same kind of attention in every way.

The result of this experiment was as follows: At the time of digging, December 29th, 1900, it was found that forty per cent. of each of the plants grown from American grown seed were pithy, while not a single stalk of the plants from the seed grown in France was pithy. The result was so pronounced that further trials were deemed necessary to verify it. The parties who had furnished the seed in the aforementioned experiments were again communicated with to ascertain further from what sources they obtained their seed. One gave an evasive answer, not knowing definitely where his seed came from, but believed it to be American grown. Another said his was American grown, while a third party wrote that he imported his directly from France. The plants and stalks from the two first-mentioned parties were alike in all particulars and, as the experiments shows, contain the same percentage of pithy stalks, while the last mentioned contained no pithy stalks.

The seeds used for the experiments during the season of 1901 were obtained from five different seed firms. These seeds were grown in the customary way. One hundred uniform plants of each were selected and planted in the same bed and given the same kind of treat-

Specimens of Pithy Stalks. Figure I. Specimens of Solid Stalks.

ment and cultivation. The plants were dug the last days of November; the result was as follows.

A's French	grown	Self-Blanching		100	stalks	1	pithy.
A's American	"	"	"	100	"	43	"
B's French	"	"	"	100	"	38	"
B's American	"	"	"	100	"	40	"
C's French	"	"	"	100	"	00	"
D's American	"	"	"	100	"	31	"
E's Selected XX		"	"	100	"	20	"

To further test whether the season of sowing the seed had anything to do with the pithiness, some seed were sown later, but there was no apparent difference in percentage of pithiness between the early and late sown seed.

A few remarks upon the general behavior of the different samples may be of interest. The stalks, from A's and C's French grown seed, were very uniform and like in all particulars, and were evidently procured from the same source in France. B's French grown was in no way different from B's American grown. The stalks were not of uniform color or size. It was evidently a mixed lot, or else the seed plants had not been carefully selected and "rogued." The stalks, from A's American grown, from B's American grown, from D's American grown, from E's Selected XX were of the same general character, both as to habit of growth and mixture of colors. The plants from the American grown seeds were not uniform in their growth, nor in their color.

The seed obtained from C, was directly imported from France; the dealer claiming that all his celery seed was imported, and that his customers demanded it even though the price for the imported seed was more than twice that of the American grown.

The soil on which these experiments were conducted is clay loam with some gravel. It was in good state of cultivation and fertility, and, while not an ideal soil for celery growing, it represented, on an average, the soils found on the truck farms around Washington and Baltimore.

The same experiment was continued through the season of 1901. Instead of transplanting the young plants into the field in the early part of the season, they were left in the seed-bed until July 26th. The seed was sown March 18th in a well-prepared seed-bed, and was given the best of culture and attention. One hundred plants of each kind were planted, side by side in the open field, giving them the same treatment and soil conditions. The plants were taken up January 20th, 1902, and gave the following results:

A's American grown seed	46	pithy	stalks.
A's French " "	00	"	"
B's American " "	43	"	"
B's French " "	26	"	"
C's American " "	38	"	"
C's French " "	00	"	"
D's Select Stock American grown seed . .	10	"	"

The results were uniformly the same as in the experiments of the two previous years. In explanation, it should be said that D's select stock of celery was American grown under the supervision of the seed firm, and had been carefully selected and cared for, showing conclusively that by proper care and selection of the best plants, the quality of the seed can be greatly improved, and the very undesirable quality of pithiness can be eliminated. Again, B's French grown seed which gave 26 pithy stalks was, to all intents, a mixture of French and American seed. This could be detected by the unevenness of the size and slight difference in color of the seed and also by the unevenness of the final product.

The remedy of this very undesirable quality of celery is to be found in the proper selection and roguing of the seed stock. Seed growers, familiar with the work, ought to know what course to pursue to gain the desired standard. Pithy stalks can easily be detected by pressing the suspected stalks between the forefinger and thumb. Anything unable to withstand a good pressure should be pulled out and destroyed. Very large-sized stalks and coarseness would also be good indications of what to throw out. Undoubtedly, such procedure would make the seed cost more to begin with, as it would entail a greater amount of labor and care than careless growing; but the gardener or trucker would willingly pay the extra cost if a superior quality of seed were guaranteed him. The cost of the seed as compared with the final value of the product is small, and should not be considered when the highest excellency is desired.

While the work done has thrown some light on the question of "Pithy Celery," still, it is only preliminary, and with the object in view of getting rid of this trouble, further experiments are on the way. Seed has been saved from pithy stalks which will be sown and account will be taken. Seed of several varieties has also been purchased from different sources in France, Germany and England, and domestic seed has been obtained from several of our leading firms.

Summary.

Taking the various points into consideration, the experiments plainly show the superiority of French-grown seed over the American-grown. That the difference is not due to the character of the soil or to climatic conditions is apparent from the fact that the celery stalks from the French seed were entirely different though they were grown

Specimens of Pithy Stalks. Figure II. Specimens of Solid Stalks.

under the same conditions of soil, climate, and were given the same kind of care. The difference must have come from the seed. We cannot accept as an established fact that the highest quality of celery seed cannot be grown in America. But we can believe that the seed is not carefully selected and grown. Pithy stalks should never be used for seed, and seed plantations should be carefully watched and rogued whenever a strange plant appears. That many of the European grown seed is superior to American grown seed cannot be disputed. The superiority is due altogether to their careful selection of seed stock, and the subsequent attention paid to the plant to keep it up to the set standard. There can be no doubt that if the American celery seed growers were as careful in their work as the French growers are, their seed would in all probabilities be as good. Cheap seed is dear at any price. This is especially true when the profit of a whole season's work is dependent upon it.

From the long correspondence with several of the leading seed firms, the view was advanced that pithiness in celery is due to conditions of soil, climate and cultivation, and that the seed is not responsible for this undesirable quality. It cannot be denied that soil and climate are very large factors in successful celery growing as effecting both size and general quality of the product, but that these are the causes of pithiness cannot be maintained in any of these experiments.

Celery Culture in Maryland.

The growing of celery on a commercial scale is with few exceptions a new feature to the truck growers of Maryland. The general impression has been that celery requires a particular kind of soil, and that the ordinary trucking lands will not produce an average crop. It is also believed that the climatic conditions were not suited to the best development of the plant. While it is true that the average trucking soil of Maryland is not an ideal soil for celery, it can be grown successfully on most lands, provided a certain amount of care is taken in the selection, preparation and fertilization of the land. The proper time of planting, spraying, watering and cultivation are also important factors on which success is often dependent.

Soil.

The ideal soil for celery is reclaimed peat-bogs or muck lands. These are composed almost entirely of vegetable matter, and when sufficiently drained and decayed produce the best quality of celery. The famous celery lands around Kalamazoo, Mich., are nothing but reclaimed peat-bogs; so are the extensive celery lands in Southern California. In the absence of such lands, celery may be grown quite successfully on ordinary garden or truck lands well-tilled and fertilized. The most essential point to bear in mind is that the land must be rich in humus or vegetable matter. For this reason soil intended for celery

should have previously been given a liberal dressing of stable manure from forty to fifty tons to the acre, and allowed to decay before the land is planted in celery. Or if this cannot be had, several crops of forage crops should be plowed under and allowed to decay. For celery the soil cannot be made too rich in humus. Next, the soil should always be deep and mellow. It is generally advisable to grow several crops of other vegetables on the land until it had reached a high state of cultivation. The land should be thoroughly plowed with a sub-soil plow to the depth of twelve to fifteen inches. Heavy clay land will, as a rule, not grow good celery and should be avoided. If clay lands are the only ones available, they should be plowed deeply with a sub-soil plow, and large dressings of barn-yard manure and green crops should be applied before the celery culture is attempted.

Water.

The importance of water in celery culture is often overlooked. The annual rainfall in most sections of the country is rarely sufficient to grow the best possible crop, and some means should be provided whereby the celery plantation can be watered during the dry spells. If the grower is so located that a stream or a creek can be diverted to the land he is most fortunate. If it is not possible, then gasoline or windmill power may be used. The cheapest and most effective means will readily suggest itself to the grower. The local conditions will also serve as a guide in this matter. Sub-irrigation has been tried with some success, but in many instances it is both expensive and impracticable. Watering with a hose or by letting in a stream of water between the rows of plants or even in the bed itself is generally the best and most economical way. After each application of water and after each rain, the land should be stirred as soon as the land will permit to break up the crust formed, and to prevent excessive evaporation. This is very important, and should never be overlooked. The more humus the soil contains, the greater will be its water-holding capacity, and the less occasion will be for watering.

Fertilizers.

The celery grower should never rely upon the use of commercial fertilizers as a substitute for barn-yard manure or manure derived from the use of cover crops. If the soil condition is not what it ought to be it cannot be made so by the use of commercial fertilizers. Nothing can take the place of well-rotted barn-yard manure applied at the rate of forty to fifty loads to the acre, and plowed under to the depth of eight inches. The land should, if possible, be planted to some hoed crops after the manure has been applied, so as to permit it to become thoroughly incorporated with the soil. The soil must be in uniform tilth before it is planted to celery. Commercial fertilizers in the form of nitrate of soda may be applied with good results in the fall of the year,

Figure III. Field of Celery Single Row System.

when due to the cold weather, the nitrifying agencies in the soil are not active, and the plants can then make good use of it, it being soluable and immediately available to the plants. It should be applied at the rate of three hundred to four hundred pounds to the acre. In applying commercial fertilizers be sure that they do not come into direct contact with the plants, as they will generally injure them, and in many instances cause death to the plant.

Sowing the Seed.

The seed for the early crop should be planted from the first to the fifteenth of March in hotbeds. These are made in the usual way. It is sometimes advisable to transplant the seed into cold frames to produce stocky and healthy plants. Shearing off the tops of the young plants is also done to make the plants stronger. For late crop, the seed may be sown in the open ground in a well-prepared seed-bed. The soil should be a rich, sandy loam, and in fine tilth, and plowed to a depth of at least ten inches. The size of the bed is a matter of convenience, long and narrow ones being preferable, as they are more easily and economically cultivated. Soils which have a tendency to bake after rain or watering should be avoided for seed-beds. The seed should always be sown in rows from six to eight inches apart to facilitate cultivation and working.

There are two general methods of field culture practiced in Maryland. One is to plant the seedling in rows five feet apart, and the plants six inches apart in the rows. Where the soil is not apt to wash badly, the plants may be set three or four inches below the surface, and the land plowed out in the manner corn is listed. Where the soil is apt to wash badly, planting below the surface should not be done, as it will often cover the plants over with soil washed down upon them. By this system, the plants may be blanched very cheaply as the soil may be moved around the plants by the use of horse labor and a larger acreage can be cared for.

The other method is what is termed the bed method. The plants are planted in row six or eight inches each way. The beds should be from eight to ten feet wide and any desirable length. If more than one bed is to be used, a space of eight to ten feet should be left between the beds for the soil to be used for filling in between the rows of celery for blanching. It is understood that the land should be put in the best possible shape before planting both as to fertility and physical condition. It is often desirable to sink the beds to about four to six inches below the surface of the soil, so as to facilitate the filling of earth for blanching and to prevent too rapid evaporation of moisture. If this is done, less space will be needed between the beds.

Figure IV. Field of Celery Bed System.

Planting.

In the single row method, the furrow, (if the celery is to be planted below the level) can be opened up with a shovel plow. It may be necessary to go over the same furrow several times to obtain an even and smooth furrow. Care should always be taken to get the plants in straight rows. To obtain this end, the line should be frequently employed.

After the furrow has been laid out, the edges of loose soil should be raked off and the soil on the sides and on the bottom of the furrow made smooth and fine to prevent washing and covering up of the plants. It is generally advisable to cut off about half of the tops of the young plants and also to trim off the longest roots. The young plants should be dipped in a puddle made by adding clay loam to water before planting. This will form a coating around the roots and in a measure protect them from drying out, while being planted. Planting should not be done during dry weather or during the warmest part of the day. Immediately after a good rain is the best time for planting. If the planting is to be done in single rows and on the top of the soil, the rows should be laid out with a line and the soil raked

smooth and fine along the line of planting. In the bed system, whether submerged beds are used or level culture, the planting should be done from the sides of the bed to prevent unnecessary packing of the soil, and for this reason, they are made narrow enough to permit the planter to reach over one-half of the bed from either side. The rows are conveniently laid out as follows: A line is stretched from one end to the other through the middle of the bed. This line is to serve as a guide for the marker, which makes the rows. The marker can be made by the grower himself and will be found a very useful tool.

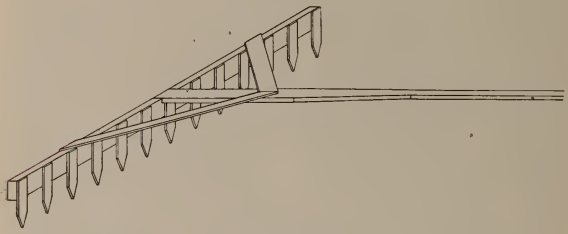


Figure V.—Marker.

The above illustration gives an idea how it is made. It consists merely of a piece of wood, two inches thick, four inches wide and six feet long, to which are nailed sticks ten inches long, two inches wide and one inch thick pointed at one end, at the distance apart you wish your rows to be. To this frame are nailed a handle and braces. Frequent cultivation to keep the soil loose and moist is absolutely necessary. Plants which have once become stunted or dwarfed in their growth will never completely recover. During the usual dry and warm spell in July and August, the plants should be watered, but care must be taken to keep the soil from baking.

The Time to Plant.

The time to set the young plants into the field depends upon whether early or late celery is wanted. If late celery is to be grown, the plants should be set from the first to the fifteenth of July. A crop of early peas or early Irish potatoes may be grown on the land first. Such crops will tend to pulverize the soil and bring it into fine tilth, before the celery is planted. Care should be taken to have the land rich enough to provide an abundance of food material for both crops. If an early crop is wanted, the plants should be planted into the open ground as soon as all danger of heavy frosts is over. Light frost will, as a rule, not injure the plants.

Cultivation.

The celery plantation should be cultivated once every ten days. Once a week would be still better. It may be stated as a fact that almost all growers cultivate too little. Thorough and frequent cultivation is as important as the application of fertilizers.

A fine-toothed cultivator is the best implement, as it leaves the soil fine and even. The soil along the row of plants and around the plants should be loosened up and fined after each cultivation. The plantation should always be cultivated and hoed as soon as possible after a rain. It should always be borne in mind that the young plants must be kept growing without check in order to produce the largest crop and finest quality. Plants, which have become stunted or dwarfed through careless and deficient cultivation, will not produce the finest quality. One often sees large plantations of young plants, which remain stationary for two or three months during the hot part of the season, and then they are expected to produce a crop, when the cool weather of the autumn comes. This is entirely wrong. No plants so treated can possibly attain the highest perfection. Do not sow the seed for both the early and late planting at the same time. The plants for late planting will be too old and woody before it is time to transplant them into the field.

If possible select a cloudy day, on which to do the planting. If this is not possible, it may be done late in the afternoon and evening. The planting is generally done by the aid of dibber or a stick, with which holes are made. The trimmed plant is then placed in the hole and the soiled is firmed about it. Care must be taken to get the hole filled well clear down to the bottom, oherwise their will be an air space, which may cause the death of the plant. If dry weather should follow the planting, it is sometimes necessary to resort to watering. Frequent and thorough cultivation will often prevent the drying out.

Spraying.

The importance of spraying cannot be overestimated. It is seldom possible to grow a clean crop of celery without it. There are two species of blight, which generally attack the celery. One is termed the Early Celery Blight, *Cercospora Apii*, and the Late Celery Blight, *Septoria Petroselini, Var. Apii*. The former often makes its appearance in the seed-bed and immediately after the plants have been set into the field. The fungus first makes its appearance on the ends of the leaves in small circular spots, which rapidly increase in number and extent. The spots are at first dull green in color and gradually change into a pale brownish yellow color. The disease spreads very rapidly during hot moist weather. The late celery blight seldom makes its appearance until autumn, and does most of its damage after the crop is grown and in many instances large losses have

been caused by it in the storage cellar. It is easily detected by reason of the dark, spotted appearance of the leaves and stalks.

Remedies.

In most cases little attention is paid to the diseases until they have done considerable damage. The real value of a fungicide lies in its preventive powers. After the disease has once gained a strong foothold, it is next to impossible to cope with it as the damage is already done, and the most a fungicide can do is to keep it in check.

Numerous experiments, with a large number of fungicides on these two blights, have demonstrated that the most effective one is the standard ammoniacal solution of copper carbonate. The following formula is recommended:

Copper carbonate, 8 oz.; Ammonia water, (26°) 3 pts.; Water, 48 gals.

In order to be most effective, the young plants should be sprayed two or three times while in the seed-bed, and once every ten days or two weeks after they are transplanted into the field. It is advisable not to make the application in the middle of the day, as the leaves are apt to be slightly injured. Late in the afternoon or evening is the best time to make the application. (For results of spraying for the prevention of celery blight, see Bulletin No. 74, of this Station).

Mulching.

Mulching of the celery plantation is to be recommended especially if the soil is light and subject to drought. Beside checking evaporation, a good mulch shades the soil and keeps it cooler than if it were left bare. The best material for mulching is well-rotten stable manure. It should be spread out between the rows and around the plants immediately after they have been set out. In order to be more effective, it should be applied from two to three inches thick. If not enough material is available to cover the entire distance between the rows immediately around the plants, the distance of eighteen inches or two feet may be covered with good results. Green clover is sometimes used for a mulch, and with good result. The clover should be cut before the bloom, as to get the largest amount of leaves and succulent materials, and should be put on about six inches thick. Clean straw and strawy manure may also be used, but the great objection to the use of these materials is that they always carry foul weed seed with them, besides being difficult to remove when the time for blanching comes. The mulch should be applied about the first week in June for early celery, and about the first week in July for late crops, the object being to keep the soil cool and moist during the hottest part of the summer, where under ordinary conditions the celery plants make little or no growth. Before blanching commences, all of the coarse mulch should be gathered up and taken off, leaving no refuse

behind. The soil used for blanching must be mellow, and, if possible, entirely free from partially decayed vegetable matter. For this reason, it is better not to use partly rotten stable manure for a mulch, as it cannot be thoroughly incorporated into the soil before it is used for blanching, and it is very apt to produce spotted celery by coming in contact with the celery stalks.

July and August are the hardest months on the celery and, during these months, the plants are very apt to become stunted and dwarfed in their growth. To prevent this mulching is recommended, or, if water can be had conveniently, the plantation should be watered frequently and kept well cultivated after each application of water.

Blanching.

The object of blanching is to obtain white, crisp and tender celery. Blanching eliminates the original green color, the bitter taste, and the natural tendency of the stalk to become tough. The most general material used in blanching is earth. There is considerable difference of opinion as to the time when the celery ought to be blanched. Many successful growers practice the system of gradual blanching, that is, the soil is banked about the plants at different times through the growing season, and by the time the celery plants have reached their maximum growth, they are already blanched and ready for the market. It is claimed, and not without reason, that celery so grown is better in quality. The stalks do not remain out of ground for any considerable length of time, and have little chance to become tough by long exposure to the atmosphere. Gradual banking also tends to keep the soil around the roots of the plants cooler, but this is not always the case. If the blanching is done gradually, care must be taken to have the soil fine and not to leave any air space around the stalks. Gradual blanching will, as a rule, also produce a whiter and more solid stalk. If the plants are allowed to grow the whole season without banking, they will have a tendency to spread somewhat, and the leaves must be tied together before the blanching process is undertaken. If the single row system has been employed in growing the plants, the blanching is a very easy matter. Furrows are plowed against the row of stalks and then the soil is worked and packed in between the plants. After this has been done, furrows are again thrown against the rows and the soil worked against the plants. This process is repeated until enough earth has been packed about the plants. The sides of the banks are then raked smooth and rows left until time for digging.

If the plants have been grown in beds, the cost and difficulty of blanching is much greater. The land between the beds is first plowed as deep as possible, and then made fine with a pulverizer, drag-board or harrow. The earth is then shoveled by hand, in between the rows, until the plants are covered to the desired depth. It is generally necessary to tie the leaves of the stalks together before the process of blanching begins.

Many growers employ a board in blanching. This is to protect the centre of the stalks and in a measure to keep the leaves together during the process. After the soil has been filled in, the board is taken out and put in place for the next row. This practice is being superseded by simply holding the leaf stalks together with a cord and then press the soil well around the stalk. The centre is then well protected and, besides, there is no danger of leaving any air space. The stalks will also be more uniformly blanched and more compact in form. The cord should not be tied around each stalk, but simply wound around them, and then carried over to the next stalk without breaking. The cord should be wound close to the top of the plants, just below the fork of the leaf-blade so as not to injure the stalk.

Blanching may also be done by the use of paper, either wrapped around the stalk and kept in place by tying a cord around it, or paper cylinders of desired size may be made out of a building paper, and these placed around the plants. Blanching may also be done by using boards. Boards of the required length are placed one on each side of the row, and kept in position by sinking the lower edges into the soil about two inches, and by driving two nails opposite each other on the upper edges and by tying these together by means of a stout twine. These methods are not recommended to be used in a commercial scale. They are, as a rule, less effective than earth, besides the quality of the celery so blanched is, as a rule, not uniform. They may be used in a small way, and good results may be obtained if the work is done carefully.

If the celery is to be stored for late use in the spring, the keeping qualities are greatly increased by blanching the celery during the period of storing. The stalks should be kept growing until danger of damage from frost without any banking of earth. They are then taken up and stored away green.

The writer is of the opinion that the system of gradual blanching and filling in of soil is better suited to the soil and climatic conditions of Maryland. Some experimental work along this line will be carried on this season.

Storing of Celery.

Storing in the Open.—Celery grown in beds and banked with soil may be safely covered with clean straw or leaves to the depth of from ten to twelve inches. The outer edges of the bed should be banked up several inches above the height of the tops of the celery stalks, so as to retain the covering. Pieces of board or branches should be laid over the covering to prevent the material from blowing off. Care must be taken to secure perfect drainage. The trenches from which the soil used for banking should be opened up, so as to permit rain and water to drain off.

If the celery has been carefully banked up during the process of blanching and sufficient covering and drainage have been provided

for, it should keep up to the middle of January, if not later. The work of digging celery stored, as described above, is quite laborious, especially during cold weather. The method has many advocates in Maryland, since it requires little or no expense in storing.

Many growers prefer to store their celery, intended for the mid-season, in trenches. These are conveniently made as follows: Select a place well-drained, and plow open a furrow to the depth of ten inches. By going over the furrow with a plow several times, it will greatly reduce the hand labor. The bottom of the furrow should then be opened up to about six inches wide. Next, take a common board, one inch thick and twelve inches wide, and place the same on the edge in the bottom of the furrow. The plants are next placed in a straight row as close as possible to each other without coming in actual contact. Then fill in with soil between the board and the plants, taking the soil first on the other side of the board for the filling. When the trench is full remove the board and set another row of plants. In this way the excavated soil is used for filling and a new trench is made at the same time. After the last row has been made, the trench by the side should be filled in to prevent water from standing in it. The length of these trenches depends upon convenience. They should be just long enough to permit the removal of one or more beds at each time. The tops are covered with straw, leaves or corn fodder, and a few boards are thrown on top to prevent the covering from blowing off. The depth of covering depends how late the celery is to remain in the trenches.

Storing Celery in Celery Houses.

When celery is grown on a large scale and for supplying a particular season, it is always advisable to construct a house for that particular purpose. A place having natural drainage should be selected. The building should be sunk three or four feet into the ground and walled up with brick. The shape of the building depends upon the surrounding conditions. A wide building is, as a rule, better than a long and narrow one, as it will keep a more even temperature, and besides, a wide building has a greater storage area. The roof should even span, if the building is situated on a level; but, if on a hillside, half span is the best. The height of the walls should be from five to six feet, so as to permit freedom of movement. The roof should be built of heavy material or of two thicknesses of inch boards, with heavy building paper between, so as to keep out the cold.

Hillside storage cellars are very popular with many growers. They are warmer and retain an even temperature and moisture much better than a building on the level.

Storing.—The bottom of the celery-house should consist of about four inches of loose sand or soil; sand being preferable, as it is less apt to harbor diseases. The sand or soil should be spread out evenly over the floor, and moistened if dry. This is important, since it is

always difficult to water the celery after it has been stored and, besides, the stalk are more apt to become diseased after being wet. If the soil is well-moistened before the celery is stored, it is seldom necessary to water again.

Before the celery is taken up, it is a good practice to have the plants loosened by means of a spade, which is thrust under the plants and then pulled out without disturbing the plants. The plants can then be pulled out by hand and placed into a box. If the celery is tender and hard to handle, it should be placed into a box; or into a cart or wagon, if the plants are strong and not easily broken. When a large acreage is grown, a special machine is used for cutting loose the plants in the field. The storage house should be laid out into beds. The boundaries of the beds should be kept by means of boards set on the edges, leaving a pathway of eighteen or twenty-four inches wide between each bed. The width of the beds depends upon the width of the building, from eighth to ten feet being the usual widths. The storage house should, if possible, have a door at each end to facilitate handling and ventilation. The roof should also be provided with ventilators. The plants are stored away as follows: A narrow trench is opened by the means of a spade and the plants placed upright in it. The soil is then shoveled around the plants by one man, while another holds the plants in position, and works the soil around them. When one trench is finished, the second trench should have been made by taking the soil of it for filling the first one. The process is repeated until the house is full.

Ventilation.

Greatest care should be taken in ventilating. So long as the outside temperature will permit, there should always be a free circulation of air through the house. The celery is particularly liable to rot and mould, if kept too close. When cold weather sets in, ventilation can be given, but sparingly and warm days should be selected, on which to give thorough ventilation.

Preparing the Celery for Market.

In removing the plants from the storage, they should be cut off a little below the ground, using for that purpose a sharp knife. Some growers pull the whole plant up, but this is not necessary. The celery is not so apt to become dirty, when the roots are cut off, and the plants can be more easily handled. The roots will do no damage in the sand or the soil, as it must be removed and a new layer put in before the next crop is stored. The celery is immediately taken to the place, where it is to be trimmed and washed. Most large growers have regular washing houses and racks or trays made of slats on which the celery is placed after being trimmed. The water is then turned

on by means of a hose, no handling being necessary except to turn the stalks over. If the celery is intended for a nearby market, they are generally tied up in bundles, holding either six or twelve stalks. These are then placed into a crate in upright positions. If the celery is to be shipped in large quantities, the celery is not often tied in bunches but simply packed in an upright position in the crate.

Careful trimming, washing and packing are important. Often a fine quality of celery is ruined by careless handling and too much stress cannot be laid upon these factors. The neatness and general appearance of the package are often the means of a profitable sale. The growing of the crop is only half of the battle and to many truckers, the easiest one. Poor product, well packed and cleaned, generally sells for more money than fine product, poorly packed and dirty.

Varieties.

For home use the following varieties are well adapted: Golden Self-blanching, and Giant Solid. For marketing—Golden Self-blanching, Giant Pascal, White Plume, and Giant Solid. Golden Self-blanching and Giant Solid being the favorites. The term "self-blanching" is often misleading to amateur growers. No celery grown under ordinary conditions and culture is self-blanching. It is true, however, that some varieties are more quickly blanched than others, but none is, strictly speaking, self-blanching.

Profits in Celery Growing.

The profits to be derived from the growing of celery is dependent upon several factors. The most important among these are: First, right kind of soil and favorable climatic conditions; secondly, personal qualifications of the grower; and thirdly, location as to market. Under ideal conditions, celery is one of the most profitable crops that can be grown. While the first outlay of money and labor is somewhat large, the return per acre under right management is larger than almost any other truck crop. After deducting all expenses, the net profit should be between one hundred (100.00) dollars and two hundred (200.00) dollars per acre.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 84. JUNE, 1902.

SOME FEEDING EXPERIMENTS WITH COWS.

By H. J. PATTERSON.

In this bulletin will be given the results of some of the feeding experiments with cows which have been conducted from time to time, from 1896 to 1901. There will also be added some general matter with reference to the feeding of cows, for the production of milk and butter with a few typical rations which will meet the average Maryland conditions.

The following is a list of the experiments reported upon in this bulletin:

1. Feeding an exclusive ration of corn meal vs. a balanced ration of mixed grains.
2. Mixed grain rations of different degrees of richness in protein.
3. Comparison of soiling corn, hay, corn fodder and new corn product for cows.
4. Test of sugar feed.

(1) COMPARISON OF AN EXCLUSIVE CORN MEAL RATION WITH A BALANCED RATION OF MIXED GRAINS.

There are many dairymen who feed nothing to their cows in the way of grain but corn meal. Some feel satisfied with the results attending such feeding, while others wonder why their cows do not give the returns that they read of or hear their neighbors tell about.

In order to learn some definite results produced under circumstances, and with cows such as the average Maryland dairyman has to deal with, the following experiments were conducted with a grain ration of corn meal only, in comparison with a balanced ration of mixed grains. The standard balanced ration used was made up of a mixture of five hundred pounds of corn meal, three hundred pounds of wheat bran and two hundred pounds of "King" or "Cream" gluten meal. The quantity of grain given was the same whether on corn meal or mixed grain ration, and varied from ten to twelve pounds per day per cow, depending upon their appetites. The roughage was a constant factor; therefore, had no effect on the result, but consisted chiefly of corn fodder and soiling corn.

There were six cows used in this test, a full description of which was given in Bulletin No. 69, but a brief description is given hereafter as follows: Cow No. 1.—Grade Jersey, showing fairly good breeding. She was fed a balanced ration the first year at the Station, and the corn meal ration in the second year.

Cow No. 2.—Grade Jersey of the same breeding, and age as No. 1. This cow was fed corn meal ration the first year at the Station, and the balanced ration the second year.

Cow No. 3.—Grade Jersey, not so well marked as Nos. 1 and 2, but from the same farm. Fed corn meal ration first year at Station, and a balanced ration the second.

Cow No. 4.—Grade Durham of beef type. This cow was fed corn meal ration the first year at the Station, and a balanced ration thereafter.

Cow No. 5.—Common cow, without any marks which would indicate any particular breeding. She was fed a balanced ration the first year at the Station, and the corn meal ration in the second year.

Cow No. 9.—A native cow of fairly good dairy type. She was fed a balanced ration the first year at the Station, and a balanced ration in the second year.

The records of the yields of milk and butter from these cows when comparing these rations are given in Tables 1, 2, 3, 4, 5 and 6.

TABLE 1—Record of Cow No. 1—Corn Meal Ration vs. Balanced Ration.

Balanced Ration 3rd to 11th month after calving. (1896-97).		Balanced Ration 9 months before calving (1893-97).		Corn Meal Ration 3rd to 11th after calving or 9 months before calving (1897-98).		Balanced Ration 3rd to 11th month after calving. 1893-99).		Balanced Ration 9 months before calving (1898-99).	
Milk lbs.	Butter lbs.	Milk lbs.	Butter lbs.	Milk lbs.	Butter lbs.	Milk lbs.	Butter lbs.	Milk lbs.	Butter lbs.
412	25.5	320	23.9	498	24.4	722	35.0	530	34.6
433	27.7	330	22.3	452	26.4	605	31.0	529	33.3
373	21.8	272	21.5	415	24.2	553	37.3	402	25.8
355	21.5	231	19.9	502	27.5	489	30.8	424	29.7
398	25.6	239	14 5	264	19.7	530	34.6	408	25.4
340	25.8	258	16.8	64	4.7	529	33.3	433	28.3
320	23.9	224	12.3	0	0	402	25.8	309	18.0
330	22.3	130	7.7	0	0	424	29.7	307	18.7
272	21.5	42	2.3	0	0	403	25.4	120	6.4
3232	218.6	2096	141.2	2195	126.9	4657	282.9	3457	220.2

In the above table is given the results of the milk and butter yields of Cow No. 1 for two years, when receiving a balanced ration with an intervening year when on a corn meal ration. These results

show strongly in favor of the balanced ration, and particularly so when comparing the yields for the corresponding periods of lactation at the beginning of the milking season.

One very noticeable result of the effects of the corn meal ration was to cause this cow to dry off rapidly and remain so for over three months before calving, while on the balanced ration she does not go dry at all, even though in milk for considerably over a year. The fact that this cow had been accustomed to an unbalanced ration before coming to us, and failed to breed promptly, and then did the same thing again after being on the corn meal ration might indicate that her food did not leave her system in the best shape for breeding. The amount of increase of product would pay extra well for the increased cost of the ration, as the balanced rations did not cost over from one to three dollars per ton more than the corn meal.

Table 2—Record of Cow No. 2—Corn Meal Ration vs. a Balanced Ration.

Corn Meal Ration first 9 months of milking period. (1896-97).		Balanced Ration corresponding period of lactation. (1897-98)		Corn Meal Ration 3rd to 11th month of lactation. (1896-97).		Balanced Ration 12th to 19th month of lactation. (1897).	
Milk lbs.	Butter lbs.	Milk lbs.	Butter lbs.	Milk lbs.	Butter lbs.	Milk lbs.	Butter lbs.
322	14.3	693	40.4	432	23.2	306	15.2
365	18.8	716	38.3	290	10.8	367	24.7
432	23.2	625	36.7	339	18.6	489	15.3
290	10.8	553	27.1	353	19.7	602	30.9
339	18.6	584	36.0	290	18.3	424	22.8
353	19.7	453	26.9	283	12.8	415	18.9
290	18.3	405	23.1	332	17.4	294	15.4
283	12.8	333	21.7	255	17.8	186	9.9
332	17.4	366	18.8	201	11.7	000	0.0
3006	153.9	4728	269.0	2775	150.3	3033	153.1

Cow No. 2 was fed a corn meal ration the first year she came to the Station. As will be seen from the results in the Table she was erratic in this year's performances, and she failed to breed promptly, so that she was in milk for nineteen months.

A comparison of the results for the corresponding periods of lactation when fed on corn meal and the balanced ration, as shown in columns one and two, show a yield of over one hundred pounds of butter and seventeen hundred pounds of milk in favor of the balanced ration.

After the cow had been in milk for eleven months, and seemed to be pretty nearly dry her feed was changed from the corn meal ration to the balanced ration of mixed grains, and she immediately began to

gain in her flow of milk, and kept up a good flow for eight more months, so that in the nineteenth month, when receiving a balanced ration, she gave nearly as much milk and butter as she did the eleventh month, when receiving the corn meal ration. The detailed results for these last eight months are given in the last two columns of Table 2.

Table 3—Record of Cow No. 3*—Corn Meal Ration vs. Balanced Ration.

Corn meal ration, 7 months of lactation period, 1896.		Balanced ration corresponding period of lactation, 1897.	
Milk lbs.	Butter lbs.	Milk lbs.	Butter lbs.
489	14.3	909	33.9
491	20 2	637	25.2
381	15.2	644	24.0
334	13.7	608	26.9
856	16.2	549	23.1
441	19.0	581	25.4
288	14.8	465	23.3
2770	113.4	4393	181.8

*Note.—Cow went dry for two months when on corn meal ration, when as previously she had not gone dry at all.

The results as obtained with Cow No. 3 are simply confirmatory of those obtained with the other cows, and show strongly in favor of using a balanced ration. The experiment could not be conducted longer on account of sickness.

Table 4—Record of Cow No. 4*—Corn Meal Ration vs. Balanced Ration.

Month of Lactation	Corn Meal Ration, corresponding period 1896.		Balanced Ration corresponding period, 1897.		Balanced Ration corresponding period, 1898.		Balanced Ration corresponding period, 1899.	
	Milk, lbs.	Butter, lbs.	Milk, lbs.	Butter, lbs.	Milk, lbs.	Butter, lbs	Milk, lbs.	Butter, lbs
2	382	15.8	674	27.4	839	37.2	648	27.2
3	377	14.1	491	21.3	625	24.8	635	25.2
4	359	12.5	520	21.8	618	28.1	634	25.9
Total	1118	42.4	1675	70.5	2082	90.1	1917	78.3

*1896—Cow dry over five months.
1897—Cow dry over four months.
1898—Cow dry over three and one-half months.

The results with Cow No. 4 bear additional testimony of the value of a balanced ration. The shorter periods for going dry when fed a balanced ration is particularly worthy of note.

Table 5—Record of Cow No. 5*—Corn Meal Ration vs. Balanced Ration.

Balanced Ration, corresponding lactation period. 1896.		Corn Meal Ration, 5th to 9th month of lactation period. 1897.	
Milk, lbs.	Butter, lbs.	Milk, lbs.	Butter, lbs.
561	26.2	481	17.4
340	11.9	426	20.9
330	14.1	374	18.7
358	16.6	376	17.9
373	16.5	203	11.8
1962	85.3	1860	86.7

*Experiment cut short with cow on account of death from acute pericardites.

The results with this cow are not so marked, yet her milk yield is in favor of the balanced ration with very little difference in the amount of butter.

Table 6—Record of Cow No. 9—Corn Meal Ration vs. Balanced Ration.

Month of lactation.	Balance Ration. 1896.		Corn Meal Ration. 1897.		Corn Meal Ration. 1896.		Balance Ration, last 6 months of lactation period. 1896.	
	Milk, lbs.	Butter, lbs.	Milk, lbs.	Butter, lbs.	Milk, lbs.	Butter, lbs.	Milk, lbs.	Butter, lbs.
1	613	32.9	.....	.....	641	29.9	.....	.....
2	533	20.5	.....	.....	702	33.6	.....	.....
3	541	28.5	.....	.....	646	28.6	.....	.....
4	609	31.3	507	21.9	633	23.6	350	22.1
5	508	20.2	403	22.6	555	20.6	310	23.2
6	421	20 6	362	20.3	461	22.6	372	24.3
7	462	23.7	486	22 0	371	19.1	401	23.8
8	391	19.6	378	22.1	262	14.7	370	21.6
9	350	22.1	194	10.4	353	20.8	326	19.4
9 Months.	4428	219 4	0000	0000	4629	213 5	0000	000.0
6 Months.	2741	137 5	2230	119.3	2640	121.4	2129	133.4

*Cow was in milk for fifteen months 1896-1897.

The feeding of this cow with corn meal was commenced the second year she was at the Station, and continued through the third year, but could not be conducted longer, as she was removed from the herd on account of sickness.

The corn meal feeding only covered the last six months of the second lactation period. The results in the table are for the respective six and nine months periods. They are all in favor of the balanced ration.

Conclusions:—From the results obtained with these six cows it would seem that there was little doubt that the profits were in favor of feeding a balanced ration of mixed grains rather than feeding corn meal only as the grain ration. The indications are that the cows keep more healthy, in better breeding form, and are in better shape for the succeeding year's work when fed a balanced ration than when fed of only corn meal. While it is not always possible for the small farmer to get the necessary grains for making a balanced ration, economically, yet a dairyman with ten or more cows can get them by purchasing by the carload direct from the wholesale dealers. The rich by-products will keep well until used; but of course it is desirable to have them fresh, and several farmers or dairymen in a community ought to cooperate and purchase together.

MIXED GRAIN RATIONS OF DIFFERENT DEGREES OF RICHNESS IN PROTEIN.

There is no point in connection with the feeding of cows which is of so much interest as that of how much protein is required, and in what proportion. To-day, among most feeders, two standards are recognized—the "German Standard," which is founded upon the results of experiments, and the "American Standard," which has been calculated from a compilation of the results of good practice of successful American dairymen. These standards vary in ratio 1.5 and the American Standard requires not only a less relative, but actually less protein than that advised by the German investigators. With an idea of studying some of this point the tests herewith recorded were made.

The cows used in this experiment had been receiving for some time uniform treatment. They were divided into two lots so that all points as to individual characteristics of breeding, amount of milk flow, and so forth, were as even as possible. The plan was to start them with rations which were not far apart in their relative ratios, and gradually get them further apart. The foods used in making up the ration were the same for both lots of cows, and only varied in the proportions used.

At the beginning lot one was continued upon the ration which had been fed to all the cows for some months, and the ratio of lot two was made narrower by adding more of the feeds richer in protein. The

feeds used in the rations were corn meal, wheat bran, gluten meal, hay and corn fodder.

The results of the feeding of these rations are given in Tables 7, 8, 9 and 10, showing the relation of protein fed in a wide and narrow ratio to products, and in Tables 11, 12, 13 and 14, showing the relation of the carbo-hydrates to the products. The summary of these results is given in Table 15.

The detailed data as to the amount of the different constituents is indicated in the heading of the tables. The requirements for maintenance is based upon the maintenance ration for an animal weighing 1,000 pounds, that is 0.7 pounds protein and 8.3 pounds carbohydrates per day.

The fourth period has no records made, as the cows were all well advanced in period of lactation and some dry. The lots were continued on the same feeds respectively.

Period five, it will be noted, was the end of one year's feeding upon these rations. The results for this period, though not showing the same figures, yet are in the same relative directions. The results would have been less varied between the lots had it not been for cows Nos. 4 and 16, which had been milking for a long time on account of failure to breed.

TABLE 7.

Showing Relation of Protein Fed in Wide and Narrow Ration to Products.

Period 1, December and January, 62 days.

Digestible Nutrients in 100 Pounds of Feed—Protein 7.8 Pounds; Carbohydrates 51.4 Pounds—Nutritive Ratio of Ration 1:6.6.

Cow No.	Weight of Cow, lbs.	Milk Yield, lbs.	Butter Yield lbs.	Food Eaten. lbs.	Protein.		
					Fed, lbs.	Used for Maintenance lbs.	Consumed for 100 lbs Milk lbs.
1	863	1059	67.9	1423	111	37	7.0
4	1023	1269	51.0	1501	117	43	5.8
10	910	880	46.2	1334	109	37	8 2
12	850	684	43 0	1368	107	37	10.2
16	910	1235	68.0	1409	110	37	5 9
19	763	1213	96 8	1501	117	31	7.1
23	1017	1379	62 5	1674	131	43	6.3
Total ..	6336	7719	435.4	10270	802	265	50.5
Average .	905	1102	62.2	1467	114	37	7.2

TABLE 7--Continued.

Digestible Nutrients in 100 Pounds of Feed—Protein 9.0 Pounds; Carbohydrates 51. Pounds—Nutritive Ratio 1:5.7.

Cow No.	Weight of Cow, lbs.	Milk Yield, lbs.	Butter Yield, lbs.	Food Eaten, lbs.	Protein.		
					Fed, lbs.	Used for Maintenance lbs.	Consumed for 100 lbs. Milk. lbs.
2	909	764	46.0	1429	123	37	12.0
7	872	1010	65.9	1487	134	37	9.6
13	805	*278	14.6	*620	156	18	13.4
15	983	1663	80.4	1673	150	43	6.4
17	842	1742	88.7	1429	129	37	5 3
21	666	1039	59.1	1225	110	31	7.6
29	925	768	39.8	1416	127	37	13.0
Total	6002	7264	394.5	9279	779	240	67.5
Average..	857	1037	56.3	1325	130	34	9.6

*30 days in test. ‡Excluded from Average.

TABLE 8.

Digestible Nutrients in 100 Pounds of Feed—Protein 7.1; Carbohydrates 48.0 Pounds—Nutritive Ratio 1:6.7. 2nd Period 43 days.

Cow No.	Weight of Cow, lbs.	Milk Yield, lbs.	Butter Yield, lbs.	Food Eaten, lbs.	Protein.		
					Fed, lbs.	Used for Maintenance lbs.	Consumed for 100 lbs. Milk, lbs.
1	857	605	38 8	1012	72	26	7.6
4	997	782	31.0	1018	72	30	5 4
10	920	510	21.4	1016	72	26	9.0
12	860	403	24.4	936	66	26	9.9
16	907	682	33.2	848	60	26	5.1
19	762	739	36.1	916	65	22	5.8
23	962	855	38.7	1166	82	26	6.6
Total ...	6265	4556	223.6	6912	489	182	49.4
Average .	895	650	31.9	987	69	26	7.1

TABLE 8—Continued.

Digestible Nutrients in 100 Pounds of Feed—Protein 9.4 Pounds; Carbohydrates 48.5 Pounds—Nutritive Ratio 1:5.2.
Second Period 43 Days.

Cow No.	Weight of Cow, lbs.	Milk Yield, lbs.	Butter Yield, lbs.	Food Eaten, lbs.	Protein.		
					Fed, lbs.	Used for Maintenance lbs	Consumed for 100 lbs. Milk. lbs.
2	903	436	21.9	1006	95	26	15.8
7	878	596	24.1	1016	96	24	11.7
13	805	439	21.9	854	80	26	12.3
15	973	1055	46.8	1124	106	30	7.2
17	836	957	44.7	1016	96	26	7.5
21	667	611	34.3	851	80	22	9.5
24	948	432	25.2	1012	95	30	15.0
Total ...	6010	4526	223.9	6939	648	186	78.8
Average.	858	646	31.9	991	92	26	11.3

TABLE 9.

Digestible Nutrients in 100 Pounds of Feed—Protein 6.5 Pounds; Carbohydrates 51.6 Pounds—Nutritive Ratio 1:7.9.
Third Period, 106 Days—March 15 to June 30.

Cow No.	Weight of Cow, lbs.	Milk Yield, lbs.	Butter Yield, lbs.	Food Eaten, lbs.	Protein.		
					Fed, lbs.	Used for Maintenance lbs.	Consumed for 100 lbs. Milk. lbs.
1	908	1366	88.4	2474	161	64	7.1
4	1032	1884	70 4	2514	163	74	4 7
10	990	716	38.9	2246	146	74	10.0
12	919	1027	63.2	2386	155	64	8.8
16	939	1312	73.4	2474	161	74	6.7
19	819	1438	86.3	2538	165	64	7 0
23	1032	1971	95.3	2908	189	74	5.8
Total ..	6639	9713	524.9	17540	1140	488	46.1
Average.	948	1387	74.9	2505	162	69	6.6

TABLE 9—Continued.

Digestible Nutrients in 100 Pounds of Feed—Protein 9.4 Pounds; Carbohydrates 48.5 Pounds—Nutritive Ratio 1:5.2.

2	964	988	59.4	2172	204	74	13.2
7	910	1678	105.1	2442	230	64	9.9
13	844	1036	50.9	2228	209	64	14.0
15	1020	2076	102.6	2792	262	74	9.0
17	886	2297	125.5	2492	234	64	7.4
21	721	1496	88.0	2074	195	53	9.5
29	1021	717	42.1	2276	214	74	19.5
Total	6366	10288	573 6	16476	1548	467	82 5
Average .	909	1469	81.9	2353	221	66	11.8

Fourth Period—July 1st to September 30th, or 92 days, cows were continued on same rations respectively; but as all were far advanced in period of lactation, and some dry, no results could be obtained.

TABLE 10.

Same Rations as Fed in Third and Fourth Periods.
Fifth Period—October and November, 61 Days.

LOT I.

Cow No.	Weight of Cow. lbs	Milk Yield. lbs.	Butter Yield. lbs.	Food Eaten lbs.	Protein.		
					Fed, lbs.	Used for Maintenance lbs.	Consumed for 100 lbs. Milk. lbs.
1	910	1348	77.1	1432	93	37	4.2
*4	1144	577	24.6	1488	97	49	8.3
10	880	1377	68.3	1350	88	37	3.7
12	813	1279	65.4	1034	67	37	2.4
*16	1000	606	32.8	1308	85	43	7.0
19	815	1097	65.9	1262	82	37	4.1
28	1070	1304	63.1	1642	107	43	4.1
Total.	6632	7588	397.2	9516	619	283	33.8
Average .	947	1184	56.7	1359	88	40	4.8

* Had not been bred and were milked continuously since beginning of experiment.

LOT II.

2	1018	960	55.5	1200	113	43	7.3
7	966	1039	69.7	1214	114	43	6.8
*13	935	395	23.1	300	28	10	5.0
†15	1010	798	42.8	714	67	21	5.9
†17	950	523	28.7	636	60	21	7.4
21	848	809	51.8	1308	123	37	9.4
29	958	1130	65.7	1164	109	43	5.9
Total	6685	5654	337.3	6536	614	218	47.7
Average .	955	807	48.2	933	87	31	6.8

*Milked 15 days. †Milked 30 days.

Standard for maintenance 0.7 pounds of protein, 8.3 pounds carbohydrates.

TABLE 11.

Showing Relation of Carbohydrates Fed in Wide and Narrow Ration to Products.

Period 1—December and January, 62 Days.

Digestible Nutrients in 100 Pounds of Feed—Protein 7.8 Pounds; Carbohydrates 51.4 Pounds—Ratio 1 :6.6.

Lot 1. Cow No.	Carbohydrates.			
	Fed, lbs.	Used for maintenance lbs.	Consumed for 100 lbs. of milk lbs.	Consumed for 1 lb. of butter lbs.
1	731	444	27.1	4.2
4	771	526	19 5	4.8
10	716	468	28 2	5.3
12	703	437	38.8	6.2
16	724	468	20.7	3.8
19	771	393	31.1	3.9
28	860	523	24.4	5.2
Total..... ...	5275	3259	189 8	33.4
Average.....	753	466	27 1	4.9

Lot II—Nutritive Ratio 1 :5.7.
Digestible Nutrients in 100 Pounds Feed—Protein 9.0 Pounds; Carbohydrates 51.0 Pounds.

2	729	468	34.1	5.7
7	758	449	30.5	4.7
13	316	202*	41.0	7.8
15	853	506	20.8	4.3
17	729	433	17.0	3.3
21	625	343	27.1	4.7
29	722	476	32.0	6.1
Total	4416	2675	202.5	36.6
Average	736	446	28.9	5.2

*Excluded from average.

TABLE 12.

Showing Relation of Carbohydrates Fed in Wide and Narrow Rations to Products.
Period 2—February 1st to March 15th, 43 Days.
Digestible Nutrients in 100 Pounds of Feed—Protein 7.1 Pounds; Carbohydrates 48.0 Pounds—Ratio 1 :6.7.

Lot 1. Cow No.	Carbohydrates.			
	Fed, lbs.	Used for Maintenace lbs.	Consumed for 100 lbs. of Milk lbs.	Consumed for 1 lb. of Butter lbs.
1	486	306	29.7	4.6
4	489	356	17.0	4.3
10	488	328	31.4	7.5
12	443	307	35.2	5.7
16	407	324	12.5	2 5
19	440	272	22.7	4.6
28	560	343	25.3	5.6
Total	3319	2236	173.8	34.8
Average	474	319	24.8	5.0

Lot II—Digestible Nutrients in 100 Pounds of Feed—Protein 9.4 Pounds; Carbohydrates 48.5 Pounds—Nutritive Ratio 1:5.2.

2	488	322	38.1	7.6
7	493	313	30.2	6.2
13	414	287	29.0	5.8
15	545	347	18.8	4.2
17	493	298	20.4	4.4
21	412	238	28.4	5.1
29	491	338	35.4	6.0
Total.....	3336	2143	200.3	39.3
Average.....	476	306	28.6	5.6

TABLE 13.

Showing Relation of Carbohydrates Fed in Wide and Narrow Rations to Products.

Period 3—March 15 to June 30, 106 Days.

Digestible Nutrients in 100 Pounds of Feed—Protein 6.5 Pounds; Carbohydrates 51.6 Pounds—Ratio 1:7.9.

Lot 1. Cow No.	Carbohydrates.			
	Fed, lbs.	Used for Maintenance, lbs.	Consumed for 100 lbs of Milk lbs.	Consumed for 1 lb. of Butter, lbs
1	1277	799	34.6	5 2
4	1297	908	20.6	4.9
10	1159	873	39.9	7.3
12	1231	809	41.0	6.6
16	1277	826	34.3	6.1
19	1310	720	41.0	6.8
23	1500	908	30.0	6.2
Total	9051	5843	241.4	43.2
Average	1293	834	34.5	6.2

Lot II—Digestible Nutrients in 100 Pounds of Feed—Protein 9.4 Pounds; Carbohydrates 48.5 Pounds—Nutritive Ratio 1:5.2.

2	1053	848	20.7	3.4
7	1184	801	22.8	3.6
13	1080	743	33.4	6.8
15	1354	897	17.1	3.4
17	1209	779	18.7	3.4
21	1006	634	24.8	4.2
29	1104	898	28.7	4.8
Total	7990	5600	166.2	29.6
Average..	1141	800	23.7	4.2

TABLE 14.

Showing Relation of Carbohydrates Fed in Wide and Narrow Ration to Products.
Period 5—October and November, 61 days.
Ration Same as Fed in Periods 3 and 4.

Lot I. Cow No.	Carbohydrates.			
	Fed, lbs.	Used for Maintenance, lbs.	Consumed for 100 lbs. of Milk. lbs.	Consumed for 1 lb. of Butter. lbs.
1	739	461	20.6	3.6
4*	768	579	32.8	7.7
10	697	445	18.3	3.7
12	533	412	9.4	1.8
16*	675	506	27.8	5.1
19	651	413	21.7	3.5
28	847	540	23.3	4.8
Total	4910	3358	153.9	30.2
Average	701	480	22.0	4.3

Lot II.—Ration Same as Fed in Periods 3 and 4.

2	582	515	7.0	1.2
7	589	489	9.6	1.4
13	145*	118*	7.0	1.2
15	346*	256*	11.2	2.1
17	308*	240*	11.1	2.4
21	634	429	26.5	4.1
29	565	485	8.0	1.3
Total	2370	1918	80.4	13.7
Average.....	592	479	11.5	1.9

*Excluded from average.

TABLE 15.

Showing Summary of Results Given in Tables 7 to 14.

Period.	Lot No.	Ratio of Rations	Carbohydrates consumed for 1 lb. Butter.	Consumed for 100 lbs. of Milk.		
				Protein	Carbohydrates.	Total Nutrients.
1	I	1:6.6	4.9	7.2	27.1	34.3
2	I	1:6.7	5.0	7.1	24.8	31.9
3	I	1:7.9	6.2	6.6	34.5	41.1
5	I	1:7.9	4.3	4.8	22.0	26.8
1	II	1:5 7	5.2	9.6	28.9	38.5
2	II	1:5.2	5.6	11.3	28.6	39.9
3	II	1:5.3	4 2	11.8	23.7	35.5
5	II	1:5 2	1.9	6.8	11.5	18.3
Average of Periods.						
1 and 2..... .	I	1:6.65	4.9	7.2	25.9	33.1
3 and 5	I	1:7.9	5.2	5.7	28.2	33.9
2 3 and 5....	II	1:5.2	3.9	10.0	21.3	31.3
2 and 3.....	II	1:5.2	4.8	11 2	26.2	37.4

RESULTS.

The results obtained in these feeding trials would seem to indicate that the American standard is certainly more economical than the German Standard, and would also seem to indicate that even the American Standard was narrower than necessary. Especially is this true when it is considered that many sections can produce the carbohydrate feeds in great abundance very cheaply, and have difficulty in growing a supply of the protein feeds. These results, together with those recorded in Section 1, would seem to put more stress on the value of variety in feeds than is generally recognized.

For a full appreciation of these results the figures in the tables should be given a careful and detailed study, particularly the nutrients consumed to give one hundred pounds of product.

Compare, for instance, the amount of protein required for one hundred pounds of milk with Lot I, period 3, with that for Lot II, average of periods 2 and 3; from which it is seen that it required 4.6 pounds less protein and only 3.7 pounds more carbohydrates, with a ration of 1:7.9 than with one of 1:5.2. In this connection due regard must be given to the relative cost of protein and carbohydrates.

This would seem to indicate that, for Maryland farmers, a ration with a ratio of 1:7.9 was more economical than the German Standard. Comparing periods 2 and 3, of Lot I, it would seem that the most economical ration would be somewhere between a ratio of 1 to 6.9 and 1 to 7.9.

This Station will take up further study upon this point in connection with a study of the different sources of protein which is now in progress.

THE NEW CORN PRODUCT AS ROUGHAGE FOR COWS.

In Bulletins Nos. 43 and 51 are reported tests of the digestibility of the new corn product with steers and horses. In Bulletin No. 63 is given some results of feeding experiments with pigs when the ration contained some of the new corn product, and in the following pages are given the results obtained by its use as roughage for milch cows in comparison with the common feeds used in this section.

The new corn product is a roughage that is of considerable interest to the farmers of the United States, as its use affords a market for what has been a waste product over large areas; and now many sections are availing of it as a cheap and good feed. There is much of it now being used in this country and in Europe for mixing with beet sugar pulp and distillery refuse in order to make them more palatable to animals.

In all the tests the cows received the same grain ration, which was made up of a mixture of 500 pounds of hominy chop, 300 pounds wheat bran and 200 pounds of "King" or "Cream" gluten meal. So that as far as the grain was concerned it was a constant factor, with the exception of the variation of the amount consumed.

Green Soiling Corn vs. New Corn Product:—At the time of changing from green feed to dry it was decided to use the new corn product as roughage. At this time there were only six cows that were available for this test. The record for these cows for the fourteen days from October 1st to 14th, when they received green soiling corn, is given in Table 1, and that for the following fourteen days, October 15th to 28th, when they received the new corn product, is given in Table 2.

From these tables it will be seen that three of the cows gained in milk yield and three lost, but that for the six cows there was a total gain of twenty-eight pounds, or two pounds per day.

When the milk yield was calculated to its butter equivalent all the cows made a gain except one. The total gain in butter was 17.2 pounds. The amount of grain consumed was twenty-nine pounds more when on the new corn product ration than with the green soiling corn, but the value of the gain in milk or butter would overbalance this.

The time of change from green to dry feed is about the most severe of any in the year, as it is almost always expected that a falling off of milk flow will occur. In this test the dry feed (New Corn Product) was able to hold its own to a remarkable degree.

TABLE I.

Quantity of Milk and Butter Produced and Feed Eaten by Cows From October 1st to 14th, 1897.
(Long Forage—Green Soiling Corn.)

Cow. No.	Milk lbs.	Per cent Butter-fat	Butter lbs.	Grain lbs.	Fodder Green-Soiling Corn.
1	197	4.2	9.6	152	488
2	293	3.2	11.0	163	630
5	194	3.1	7.0	158	630
7	281	4.0	13.1	162	630
9	187	3.7	8.1	162	493
18	300	3.1	10.9	168	630
Totals..	1453	. .....	59.7	965	3501

TABLE II.

Quantity of Milk and Butter Produced and Feed Eaten by Cows, From October 15th to 28th, 1897.
(Long Forage—New Corn Product.)

Cow No.	Milk lbs.	Per cent Butter fat.	Butter lbs.	Grain lbs.	New Corn Product.
1	212	5.0	12.4	178	133
3	277	3.8	16.7	168	131
5	227	4.2	11.1	162	121
7	220	5.0	12.8	162	140
9	176	4.8	9.8	162	147
18	269	4.5	14.1	162	134
Totals.....	1481		76.9	994	816

Comparison of Hay, Corn Fodder and the New Corn Product:—In this portion of the test it was desired to test the new corn product with the dry roughage available on most farms; ordinary mixed timothy and clover hay (timothy predominating) and shredded corn fodder, such as is described and used in the tests reported in Bulletins Nos. 41 and 43. In all the tests the cows were given all the roughage they would eat. The details of these tests, with results of same, are given in Tables 3, 4, 5, 6 and 7.

In summary of Table 3 it will be noted that the six cows on experiment for two months produced more milk and butter, and on a less weight of feed, with the new corn product roughage, than with the mixed hay and shredded corn fodder roughage.

In Table 4 the summary for the six cows on experiment for three months showed the new corn product to produce more butter but less milk than the hay and fodder ration. There was less food consumed when feeding the new corn product.

TABLE III.

Results for Cows Under Experiment for Two Months.

Month and Kind of Roughage.	Product and Food Consumed, in Pounds.							
	Cow No 1.				Cow No. 5.			
(30 Days for Each Month.)	Milk.	Butter.	Grain.	Long Forage.	Milk	Butter.	Grain.	Long Forage
1897-8.								
November.								
New Corn Product	415	24.2	360	273	374	18.7	360	316
December.								
Mixed Hay.....	485	26.6	352	346	364	17.3	355	304
	Cow No. 4.				Cow No. 17.			
January.								
New Corn Product	812	36.0	388	197	630	29.4	360	273
February.								
Shredded Corn Fodder..	669	26 6	418	315	612	32.9	360	300
	Cow No. 12.				Cow No. 13			
January.								
New Corn Product.....	729	40.0	360	273	756	40.3	360	346
February.								
Shredded Corn Fodder..	691	37.1	346	300	629	32.2	412	356

Summary.	Product.		Food Consumed.		
	Milk, lbs.	Butter, lbs.	Grain, lbs.	Roughage, lbs.	Total, lbs.
Roughage—New Corn Product 6 Cows.....	3716	188 8	2188	1778	3966
" Hay and Corn Fodder, 6 Cows.	3450	172.7	2142	2011	4253

TABLE IV.

Results for Cows Under Experiment for Three Months.

Roughage and Cow No. (30 days for each month) 1897-98.	Product.		Food Consumed.		
	Milk, lbs.	Butter, lbs.	Grain lbs.	Roughage, lbs.	Total, lbs.
Cow No 3.					
Average for Nov. and Jan New Corn Product	500	22.8	360	338	698
December—Mixed Hay	562	23.6	360	410	770
Cow No. 7.					
Average for Nov. and Jan. New Corn Product	503	32.2	360	315	675
December—Mixed Hay	545	30.5	360	380	740
Cow No. 9					
Average for Nov. and Jan. New Corn Product	364	20.9	360	317	677
December—Mixed Hay	470	21.3	360	410	770
Cow No. 15.					
January—New Corn Product	804	37.4	387	310	697
Average for Dec. and Feb., Hay and Shredded Corn Fodder	806	32.3	412	378	790
Cow No 16.					
January—New Corn Product	657	35.2	360	335	695
Average for Dec and Feb., Hay and Shredded Corn Fodder	670	34.3	360	322	682
Cow No. 19.					
January—New Corn Product	825	47.1	360	350	710
Average for Dec. and Feb , Hay and Shredded Corn Fodder	818	45.1	360	329	689
SUMMARY.					
Total for 3 Cows, New Corn Product.	1367	75.9	1080	970	2050
Total for 3 Cows, Mixed Hay	1577	75.4	1080	1200	2280
Total for 3 Cows, New Corn Product.	2286	119.7	1107	995	2102
Total for 3 Cows, Hay and Shredded Corn Fodder.	2294	111.7	1132	1029	2151
Total for 6 Cows, New Corn Product.	3653	195.6	2187	1965	4152
Total for 6 Cows, Hay and Fodder	3871	187.1	2212	2229	4441

TABLE V.

Detailed Results of Cows Under Experiment for Four Consecutive Months.

Month, Kind of Roughage and Cow No. (30 day for each month), 1897-98.	Product.		Food Consumed.		
	Milk, lbs.	Butter lbs.	Grain lbs.	Roughage, lbs.	Total lbs.
Cow No. 2.					
November—New Corn Product	693	40.4	360	324	684
December—Mixed Hay	693	37.0	360	400	760
January—New Corn Product	605	35.3	360	316	676
February—Shredded Corn Fodder	592	29.0	406	356	762
Total for 2 months on New Corn Product	1298	75.8	720	640	1370
Total for 2 months on Hay and Fodder	1285	66.0	766	756	1522
Cow No. 10.					
November—New Corn Product	771	32.4	360	324	684
December—Mixed Hay	809	32.0	360	396	756
January—New Corn Product	698	32.5	360	296	656
February—Shredded Corn Procuct	643	32.3	360	300	660
Total for 2 months on New Corn Product	1469	64.9	720	620	1340
Total for 2 months on Hay and Fodder	1452	64.3	720	696	1416
Cow No. 11.					
November—New Corn Product	678	35.6	403	392	795
December—Mixed Hay	722	32.8	521	398	919
January—New Corn Product	652	30.5	532	362	894
February—Shredded Fodder	580	35.8	540	300	840
Total for 2 months on New Corn Product	1330	66.1	935	754	1689
Total for 2 months on Hay and Fodder	1302	68.6	1061	698	1759
Cow No. 18.					
November—New Corn Product	609	29.9	360	341	701
December—Mixed Hay	664	31.1	406	410	816
January—New Corn Product	551	30.8	376	300	676
February—Shredded Corn Fodder	484	27.6	418	358	776
Total for 2 months on New Corn Product	1160	60.7	736	641	1377
Total for 2 months on Hay and Fodder	1148	58.7	824	768	1592
Cow No. 28.					
November—New Corn Product	735	31.7	380	350	730
December—Mixed Hay	858	36.0	419	410	829
January—New Corn Product	792	36.9	360	347	707
February—Shredded Corn Fodder	689	31.4	418	358	776
Total for 2 months on New Corn Product	1527	68.6	740	697	1437
Total for 2 months on Hay and Fodder	1547	67.4	837	768	1605

TABLE V—Continued.

Detailed Results of Cows Under Experiment for Four Consecutive Months.

Month, Kind of Roughage and Cow No. (30 days for each month) 1897-98.	Product.		Food Consumed.		
	Milk, lbs.	Butter lbs.	Grain lbs.	Roughage, lbs.	Total lbs.
Cow No. 29.					
November—New Corn Product.....	709	38.0	360	343	703
December—Mixed Hay.....	710	34.8	360	354	714
January—New Corn Product.....	636	37.6	360	344	704
February—Shredded Corn Fodder.,	579	32.5	360	300	660
Total for 2 months on New Corn Product.....	1346	75.6	720	687	1407
Total for 2 months on Hay and Fodder.....	1289	67.3	720	654	1374

TABLE VI.

Summary of Results for Six Cows (Nos. 2, 10, 11, 18, 28, 29), Which Were Under Experiment for Four Consecutive Months.

Month and Kind of Roughage (30 days for each month).	Product.		Food Consumed.		
	Milk, lbs.	Butter lbs.	Grain lbs.	Roughage lbs.	Total, lbs.
November—New Corn Product.....	4198	208.0	2223	2074	4297
December—Mixed Hay	4455	204.6	2427	2369	4796
January—New Corn Product.....	3936	203.7	2349	1869	4218
February—Shredded Corn Fodder...	3570	188.4	2511	1974	4485
Totals for 2 months on N C. P.....	8134	411.7	4572	3943	8515
Total for 2 months on Hay and Fodder	8025	393.0	4938	4343	9281

TABLE VII.

Summary of Results of all Cows Fed the New Corn Product, in Comparison With Other Long Feeds (Roughage).

Month and Kind of Roughage (30 days for each month). 1897-8.	Product.		Food Consumed		
	Milk lbs.	Butter lbs.	Grain lbs.	Roughage, lbs.	Total lbs.
Period I. (Cows No. 1, 2 3, 5, 7, 9, 10 11 18, 28, 29.)					
November—New Corn Product.....	6404	323.9	4023	3679	7702
December—Mixed Hay.....	6882	323.6	4213	4308	8521
Period II. (Cows No. 2 3, 7. 9 10, 11, 15, 16, 18. 19. 28 and 29.)					
December—Mixed Hay.....	8491	391.5	4629	4670	9299
January—New Corn Product	7535	402.0	4535	3882	8417
Period III. (Cows No. 2, 4 10, 11, 12, 13, 15, 16, 17, 18, 19. 23 and 29.)					
January—New Corn Product	9148	469.2	4923	4149	9072
February—Shredded Corn Fodder ...	8296	428.9	5178	4199	9377

The summary for the six cows on experiment for four consecutive months, Table 6, shows the new corn product to produce more milk and butter on less feed than the hay and fodder. In the hay period there was more milk produced, but it yielded less butter.

The summary of all the results, as given in Table 7, shows the new corn product to be a good and economical roughage for milch cows. In some cases it did not produce as large an amount of milk, but the yield of butter was greater than when the cows were fed on hay and fodder.

(4) TEST OF SUGAR FEED RATION.

In July, 1901, there was sent to the Station samples of a feed called "Sugar Feed," which, in general appearance, seemed to have as a base ground fodder or hay. The manufacturers claimed that this feed was made up so as to serve as a complete ration and contained about 12 per cent. of sugar. The odor was pleasant and appetizing and the taste sweet. From the fact that this "Sugar Feed" resembled closely some of those which have been tested at this Station using the New Corn product base, it was decided to make a test of it, so as to have as much data as possible on such a class of rations.

The Sugar Feed is made up of a mixture of ground fodder, some grains and beet molasses, and showed the following analysis:

Water	11.80 per cent.
Ash	5.77 per cent.
Protein	16.97 per cent.
Crude Fiber	12.34 per cent.
Nitrogen Free Extract	51.25 per cent.
Fat	1.87 per cent.
Total	100.00 per cent.

This ration, as nearly as can be calculated, would have approximately a nutritive ratio of 1 to 6, and hence would be fairly well adapted for feeding milch cows.

In making the test of this feed seven cows were used. Four cows were fed exclusively on the sugar feed and three others used as check cows for comparison. Previous to entering upon the test all the cows were receiving the same ration, which consisted of a grain ration made up of hominy chop, wheat bran and gluten meal, with second crops grass for roughage. The grass was a mixture of orchard grass and clover.

On October 26th cows Nos. 12, 36, 37 and 41 were put on the sugar feed ration, and cows Nos. 15, 21 and 39 continued on the grain and grass ration above mentioned. In commencing the feeding of the sugar feed they were given only a small quantity, and gradually brought up to all they would eat. The cows were started at ten pounds per feed, twice a day, or twenty pounds per day. No. 41 was the only cow that seemed to relish the food at the beginning. In six days cow No. 41 worked up to thirty pounds of sugar feed per day, and then dropped back to twenty-eight pounds per day, which amount she continued to consume daily. Cow No. 37 refused the feed at first, but gradually came up to twenty-six pounds per day. Cow No. 36 ate twenty-eight pounds per day, and Cow No. 12 ate twenty-four pounds per day.

At all times all the cows seemed not to be entirely satisfied with the ration, and ate considerable of their straw bedding, and seemed anxious to get at the feed which the other cows of the herd were receiving.

The amount of food eaten the week previous to entering the test and during the test by the two lots of cows is given in Tables 1, 2 and 3.

The results of the milk yields are given in the following tables, 4 and 5.

At the expiration of sixteen days the ration of the two lots were reversed, so that cows Nos. 12, 36, 37 and 41 were placed again on the grain and grass ration, and Cows Nos. 15, 21 and 39 were placed on the sugar feed ration. As in the previous case, they were fed small quantities at first and gradually increased. Cow No. 39 was the only one that took to the feed. Cow No. 21 ate it only after mixing it with an equal quantity of grain, and No. 15 refused it entirely, even though

tried in every way for twelve days. Cow No. 39, which ate the sugar feed well, made an average gain of two pounds per day in her milk yield.

Cows Nos. 15 and 21 decreased considerably in their milk from lack of sufficient food, as they did not eat well. Cows of Lot II decreased in their yields an average of two pounds per day when changed from the sugar feed back to the grain and grass ration.

TABLE I.

Feed Eaten by Cows in the Test the Week Before Giving Sugar Feed.

Cows fed grass throughout, Cow No.	Total Grass, lbs.	Total Grain, lbs.	Grass per day, lbs.	Grain per day, lbs.
Lot I.				
15	224	84	32	12
21	210	70	30	10
39	210	70	30	10
Lot II. Cow fed Sugar feed test.				
12	210	56	30	8
36	210	70	30	10
37	210	70	30	10
41	210	70	30	10

TABLE 2.

Grass and Grain Given to Three Cows During the Test (Duration of Test, 16 Days).

Cow No.	Total Grass, lbs.	Total Grain, lbs.	Grass per day, lbs.	Grain per day, lbs.
Lot II.				
15	597	234	37	14.6
21	579	178	36	11.0
39	597	160	37	10.0

TABLE 3.

Sugar Feed Fed to Four Cows in Test.

Cow No.	Total Sugar Feed Eaten, lbs.	Sugar Feed Eaten per day. lbs.
Lot II.		
12	392	24.6
36	448	28.0
37	416	26.0
41	459	23.0

TABLE 5.

Records of Cows in the Experiment Receiving Sugar Feed.

Cow No.	Milk given in 7 days before test. lbs.	Milk given in 16 days of test. lbs.	Average daily yield before test. lbs.	Average daily yield last 10 days of test. lbs.
Lot II.				
12	94.9	266.5	13.5	17.6
36	113.8	282.9	16.3	18.0
37	99.2	260.9	14.2	16.9
41	132.5	341.7	18.9	22.1
Average			15.7	18.6
Gain in favor of sugar feed per day				2.9

TABLE 4.

Record of Check Cows Receiving Grass and Grain.

Lot I.				
15	150.5	396.2	21.5	26.0
21	102.0	221.7	14.7	14.2
39	114.8	253.1	16.4	16.0
Average			17.5	18.7
Gain per day of tests				1.2

CONCLUSION.

Considering the fact that all of the cows that ate the sugar feed well made a gain in the milk yield, and those cows which were eating it well dropped back in the milk yield when the sugar feed was discontinued, it would seem that this feed had considerable value as a food for cows, and was capable of serving as a complete ration. The fact that the cows ate it poorly at first, and some cows refused it entirely, cannot be taken as having much importance, one way or the

other, in determining the true value of a food from the fact that appetite for many things with cows, as with people, depends upon an acquired taste, and the more highly cows are fed the more reluctant they are to take kindly to radical changes in rations, particularly if the accustomed feeds are still in sight and being fed to some cows in the stable.

PROTEIN.

Can Dairymen Produce the Necessary Protein Feeds Profitably on Their Own Farms?*

There is no question which is of so much importance to the dairy farmer as the proper feeding of his cows so as to obtain not only the greatest amount of product, but also to procure that product at the least cost per pound. The progressive dairyman has come to recognize that protein is a necessary constituent to accomplish this end. At first it seemed a simple matter to turn to the markets and purchase the protein which the home-grown feeds did not furnish. But even under the most favorable condition of purchasing protein the amount paid out for feed represents a large percentage of the gross income, which must materially cut down the profits. In this day, when the demand for this class of feeds has largely increased, both for foreign and home consumption, and the price of our products relatively less, it has become a very important and lively subject to consider how the amount of protein required can be produced on each and every farm. Not only is it necessary to find out the crops that can be grown so as to furnish the required protein, but it is also essential to determine the crops which will furnish this protein profitably and most economically. The question of the home production of protein is much more important for the eastern dairyman than for his western brother, from the fact that protein feeds are much cheaper in the west than the east, which, together with the fact of its always being cheaper to market a finished product rather than the raw materials, places the already keen competition between the eastern and western dairy products still more to the advantage of the west. This fact is also true as to the production of all classes of animal products.

There is no doubt that the Home Production of Protein is the pertinent question of the day for the eastern dairyman and stockman. How to answer this question and solve the various problems connected therewith are more or less difficult, and will require each person or community to make some individual calculations and modifications of anything that might be said in this connection, yet, it may be possible to make some suggestions at this time that will aid or point the

*This is a synopsis of a talk upon this subject which has been given at a number of farmer meetings, and is published in this connection n order to supply the numerous requests which have been made for copies of the same.

way to some in making a satisfactory solution of the present difficulties.

For an intelligent consideration of this question turn to the figures given in Table 1, and study the various crops which are commonly raised on the farm, and see how much protein is being produced, and then turn to those crops which are not commonly grown, but which may be adopted on the farm in question, and calculate how it would be best to proceed to produce that which is required.

By observing the nutritive ratios in the two parts of Table 1, it will be seen that those in part 1, with the exception of the ratio for clover, hay and oats, are wider than the requirements of a standard ration, and also that it would be impossible to make a combination of the crops in part 1, so as to furnish the required relation of the protein and carbohydrates. The crops in part 2 have relatively narrow ratios, and can be used for making balanced rations, as is manifested by a study of the illustrations given in Tables II and III.

There are numerous other crops that might be included in the estimates and combinations, which are not given in Tables I and II, but these will serve to point the way. For instance, those sections which are further north, and not well adapted to cow peas, might substitute the Canada pea. In this connection be it remembered that cow peas are really beans, and belong properly to the bean family, and are hot weather crops. For best results they should not be planted until the ground is thoroughly warm (after June 1st), and they will be killed off with the first frosts of the fall. The Canada pea is a cool weather plant, and can be planted very early in the spring, as oats and barley, but it is impatient of hot, dry weather, and hence not adapted to the south.

Often considerably more forage can be grown to the acre by combining some of the legumes with a cereal, for example, Canada peas and oats; Canada peas and barley; winter oats or barley and winter vetch; winter vetch and wheat; cow peas and sorghum; cow peas and corn; cow peas, corn and millet. All of these combinations have been used in different sections with excellent results.

In Table II are given some sample rotations which might be suggestive as to the ways in which rotations common to parts of this State might be modified, so as to better meet the requirements of dairy farms. Rotation "A" is one that is used in part at this Station quite satisfactorily, and our experiments indicate it could be used as a whole. This rotation to some is objectionable, as it requires frequent plowing, and thus incurs considerable expense for labor. Supplementing the rotations, as shown in "B," "C" and "D," Table II, with alfalfa, it will be seen, is a very effective means of furnishing the required protein, and does not necessitate any more plowing, but really less, than at present. These schemes would make it necessary to put from one-fifth to one-seventh of the land devoted to crops for feeding the dairy down to alfalfa. Alfalfa, when once established, will stand for six to ten years. Results of tests thus far seem to indicate that alfalfa can

be successfully grown in most parts of this State, and that during August or the first of September is the proper time for seeding.

From the digestion and feeding experiments which have been conducted, it has been found that the protein of alfalfa hay can be used as a substitute for wheat bran, and cow peas will answer nearly as well as the alfalfa.

It will be noted that the rotations as given in Table II will furnish enough feed of a balanced character, according to the Western Standard, to maintain a cow on from one and one-half to two acres.

The yields outlined herewith in Tables I and II are only such as would be considered fair and satisfactory. Many farmers are producing much more. The ideal in dairying of maintaining a cow on one acre means that this must be done to a large extent by increasing the yields and using the combinations which have been suggested. The value of the leguminous crops for gathering of nitrogen and mining of subsoil fertility must not be overlooked in the matter of the economical procuring of protein, and is an additional argument for introducing these crops in the farm rotations.

Cost of Producing vs. Buying of Protein.

From the figures and discussions in the preceding pages it is very evident that the necessary protein can be produced on the farm; but this is only one phase of the question, and still leaves the question of the cost of production for consideration.

An examination of Tables I and III will show that one acre of cow peas will produce about as much digestible protein as is furnished by two tons of wheat bran, which would make the product of one acre of cow-pea hay worth $35.00 on the basis of the present market value of bran ($20.00 per ton). The cost of producing one acre of cow-pea hay would vary from $10.00 to $15.00.

One acre in alfalfa would yield the equivalent $80.00 worth of protein if purchased in wheat bran or, in other words, a five-acre field of alfalfa would yield as much protein as is purchased in a 20-ton carload of wheat bran. Of course protein can be purchased cheaper in cottonseed meal, linseed meal, and gluten meal than in wheat bran, but even with these protein can be produced by alfalfa or cow peas at about one-half their cost.

These figures, together with the fact of the leguminous crops being soil improvers, and that they can be grown often as catch crops between the regular crops, leave but little doubt as to the wisdom and profit of the home production of protein. It may be that some of these most promising crops are not adapted to individual conditions, yet there are some crops rich in protein adapted to each and every condition, and the margin of profit is large enough to warrant all in searching for the crops that can be grown and then producing the required protein at home.

Protein in Pastures.

Much might be contributed towards feeding dairy cattle by the improvement of the permanent pastures. Almost every farm has a small area that would be more profitable for a permanent pasture than for cultivated crops. On such areas it would pay well, for the trouble and expenses, if they were well prepared and set to crops adapted for pasture purposes. There are numerous grasses and some legumes that are specially adapted for pasture purposes, and which are of little value for hay purposes.

The grasses especially adapted for pastures will stand the tramping and cropping to which they are subjected, and every one knows how soon a clover and timothy sod gives out under such treatment. Among the grasses best adapted for pasture purposes in most of this State might be mentioned the following: Kentucky blue grass, Rhode Island bent, Red top and Orchard grass. These should be supplemented at time of seeding with a liberal amount of white clover and some alsyke and red clover. In some sections the Japan clover will be found to do well and is a valuable addition. The Japan clover is an annual which will seed itself from year to year.

What Feeds on the Market are the best Sources of Protein.

Some farmers may be so located that it will be necessary to supplement the home grown feeds. In such cases the question arises, "What shall be purchased?" On most farms there is generally an abundance of the feeds rich in carbohydrates, and it is desired to buy those which can be used to best advantage in balancing the dairy ration. Under such circumstances it will generally be found that to purchase the most concentrated protein food compatible with price is best.

The figures given in Table III show that, at the present market conditions, protein can be procured cheapest in cottonseed meal. The next source is gluten meal and the most expensive source is the one most commonly depended upon by farmers; namely, wheat bran.

Table III will serve to make calculations when market conditions change.

Very often farmers desire to purchase protein feeds in quantity and do not care for more than one kind, and desire something that can be used for all classes of stock. In such cases, cottonseed meal would not be advisable as it could not be used for hogs, chickens or horses.

Increasing the Supply of Protein by Plant Breeding.

The most recent experiments in plant improvement by breeding and selection indicates that a great deal can be done towards increasing the supply of protein by increasing the percentage of protein in the crops raised on the farm. It is well known that special qualities in animals have been produced by selection and breeding. Plants are

not unlike animals in this respect, and if the same laws are observed the future will find distinct breeds or types of our various crops possessing special characteristics as to the relative amounts of the valuable constituents.

What may be accomplished by plant breeding is well illustrated by the improvements made in the sugar content of the sugar beet, sorghum and sugar cane. In Table IV is exhibited what might be expected as the ultimate outcome of plant improvement by selecting and breeding, if the highest types of which there is knowledge were to be used as a basis. From this table it will be seen that there are great possibilities even with those crops which have been commonly raised on the farms of this State for years. From present indications the corn plant presents not only the easiest subject for improvement, but also seems to possess the greatest possibilities.

It must be remembered that when the protein content of the crops is increased the carbohydrates are diminished proportionately; consequently the nutritive ration is narrowed, and with the full realization of the facts, as set forth in Table IV, there would be no difficulty in balancing a ration with the ordinary products of the farm. It is essential that every farmer who expects to keep pace with the times and be able to cope with the competition of the future, should start at once upon the improvement of the breed of his crops, especially of the corn crop, with more protein for the goal.

There has been fifty samples of corn submitted to this Station for analysis by farmers who are taking up the question of breeding up the corn crop. These samples showed a range of from 8 to 12.5 per cent. of protein, which, with a ten-barrel crop, would be equivalent to a range of one hundred and fifty-seven pounds of protein per acre. Crops cannot be improved at one place for all, but will have to be done in different sections, so as to have the crop adapted to the various climatic and soil conditions.

Improvement of the crop will necessitate the improvement of the soil, and, in fact, a rich soil will have much influence in bringing up the protein content of the crop, and this will be another reason for availing of the value of the leguminous crops as agents for soil improvement.

Sample Rations.

In Table V are given some sample rations, which serve to show how much leguminous crops as alfalfa and cow peas can be used in making balanced rations, and they illustrate their advantage over the common crops of the farm, which an examination of the table shows are deficient in protein, and need to be supplemented by some of the rich by-products.

In furnishing an abundance of protein feeds the farmer has accomplished much in the way of improving the yield of animal products, but must not rest easy or think that this is all-sufficient, but remember that there is much truth in the adage, "The eye of the master fattens his cattle."

PART I. Crops Commonly Raised.	Fair Average Yield.	Per Cent. Protein.	Yield Per Acre.			Nutritive Ratio.
			Total Protein. lbs.	Digestible Protein. lbs.	Digestible Carbohydrates (fat x 2½) lbs.	
Corn (Grain and Cob)	10 bbls... 3 00 lbs...	8.5	208	167	1 505	1:15.0
Corn Fodder	3000 lbs...	3.8	114	64	1,152	1:18.0
				231	2,657	
Barley (Grain)	40 bush .. 1600 lbs...	12.4	238	193	1,544	1:78.0
Barley (Straw)	3000 lbs...	3.5	105	42	1,377	1:32.8
				235	2,921	
Oats (Grain)	50 bush.. 1600 lbs...	11.8	189	155	899	1:5.8
Oats (Straw)	2500 lbs...	4.0	100	40	1 320	1.33.0
				195	2,219	
Wheat (Grain)	25 bush. 1500 lbs...	11.8	177	136	1 346	1:9.9
Wheat (Straw)	2700 lbs...	3.4	82	33	2,161	1:65.5
				169	3 507	
Timothy Hay	2 tons ..	5.9	236	111	1 798	1:16.2
Orchard Grass Hay	2 tons ...	8.1	324	183	1 814	1: 9.4
Red Clover Hay	2 tons...	12.3	492	285	1 710	1: 6.0
PART II. Crops Not Commonly Raised in this Section.						
Cow Peas (Green)	10 tons...					
Cow Peas (Hay)	2 tons ...	16.6	664	432	1,648	1: 3.8
Cow Peas (Grain)	20 bush.. 1200 lbs...	20.8	250	207	679	1:33.
Soja Beans (Green)	8 tons....					
Soja Beans (Hay)	2½ tons..	14.5	725	515	2,311	
Soja Beans (Grain)	25 bush. 1500 lbs..	34.0	510	465	805	1: 1.7
Alfalfa Hay	4 tons	14.3	1,144	824	3,378	1: 4.1

TABLE 2—Protein Yields of Sample Rotations.

(One Acre in Each Crop.)

ROTATION A.

	Digestible Protein lbs.	Digestible Carbohydrates and Fat lbs.
1 Corn and Fodder	231	2,657
2 C. Clover Hay	285	1,710
2 C. Pea Hay	538	2,050
3 Winter Barley	235	2,921
4 Clover Hay	285	1,710
Total Rotation	1,574	11 056
Nutritive Ratio of Ration 1:7.0.		

ROTATION B.

	Digestible Protein lbs.	Digestible Carbohydrates and Fat, lbs.
1 Corn	231	2,657
2 Wheat	136	1,346
3 Clover	285	1,710
4 Timothy	111	1,798
	763	7,511
Nutritive Ratio	1:9.8	
Supplem'td by Alfalfa	824	3.378
Nutritive Ratio 1:6.86.	1,587	10,889

ROTATION C.

1 Corn	231	2,657
2 Oats	195	2,219
3 Wheat (Sold)	.....	.....
4 Clover	285	1,710
5 Timothy	111	1,798
	622	8,384
Nutritive Ratio 1:10.2.	824	.....
Alfalfa:	....	3,378
Nutritive Ratio 1:7.1	1,646	11.762

ROTATION D.

1 Corn	231	2,657
2 ½ Oats	97	1,110
2 ½ C. Pea Hay	269	1,029
3 Wheat (Sold)	.....	.....
4 Clover	285	1,710
5 Timothy	111	1,798
Supplem'ted by Alfalfa	824	3,378
Nutritive Ratio 1:6.4.	1,817	11,682

This would give enough feed to keep two cows for one year, feeding them on the basis of two pounds of protein per day each, which would be the equivalent of one cow to each two acres.

In Rotation C and D the wheat and one crop of timothy are not included in the calculations of the nutritive values, but permits of these crops being sold, as is the usual custom.

TABLE 3—Principal Protein Feeds on Our Markets.

	Per cent. Protein	Total Protein lbs.	Digestible Protein lbs	Digestible Carbohydrate (fat x 2½) lbs.	Nutritive Ratio.
Cotton Seed Meal.....	42	840	761	874	1:1.2
Linseed Meal (New Process)	39	780	663	898	1:1.6
Linseed Meal (Old Process).	36	720	640	970	1:1.7
Gluten Meal.....	38	760	669	1,450	1:1.9
Gluten Feed.....	25	500	430	1,266	1:3.4
Malt Sprouts..... ...	24	480	384	806	1:2.2
Brewer's Grains.....	24	480	379	942	1:3.0
Buckwheat Middlings.....	28	560	460	1,010	1:2.2
Wheat Bran	16	320	250	908	1:3.9
Wheat Middlings.....	16	320	260	1,220	1:4.8

TABLE 4—Showing Means of Increasing Yield of Protein by Crop Improvement.

(Average Yield Per Acre.)

	Per cent. of Protein.	Total Protein per Acre. lbs.	Digestible Protein per Acre lbs.
50 bush. Corn, average Protein.	8.5	298	167
50 bush. Corn, high in Protein	14.0	490	274
50 bush. Oats, average Protein	11.8	189	155
50 bush. Oats high in Protein.....	14.4	230	189
40 bush. Barley, average Protein.....	12.4	238	198
40 bush. Barley, high in Protein.....	15.7	301	244
25 bush. Wheat, average Protein..	11.8	177	136
25 bush. Wheat, high in Protein ...	16.6	249	192
2 tons Clover Hay, average Protein....	12.3	492	285
2 tons Clover Hay, high in Protein.....	20.5	820	475
2½ tons Cow Peas, average Protein.	16.6	830	538
2½ tons Cow Peas, high in Protein	20.0	1,000	650
4 tons Alfalfa, average Protein.....	14.3	1,144	824
4 tons Alfalfa high in Protein.....	20.3	1.624	1 169

TABLE 5—Dairy Feeding Standards and Some Sample Rations.

	Quantity.	Protein lbs.	Carbohydrates lbs.	Nutritive Ratio.
German Standard Ration		2.5	13.4	1:5.4
Wisconsin Estimated Ration		2.2	14.9	1:6.8
May and June Pasture Grass				1:5.6
Corn and Cob Meal	10 lbs.	.44	6.65	
Alfalfa Hay	15 "	1.65	6.34	1:6.2
		2.09	12.99	
Corn Meal	10 "	.53	5.91	
Clover Hay	15 "	1.02	5.94	
		1.55	11.85	1:7.6
Cream Gluten Meal	2 "	.64	1.45	
		2 19	13.30	1:6.0
Corn Meal	10 "	53	5.91	
Cow Pea Hay	15 "	1.40	5.76	
		1.93	11.67	1:6.0
Corn and Cob Meal	12 "	.53	7.98	
Cow pea hay	15 "	1.40	5.76	
		1.93	13.74	1:6.6
Corn Silage	30 "	.27	3.87	
Clover hay	6 "	.41	2.38	
Gambrill's Middlings	6 "	.77	3.64	
		1.45	9.89	1:6.9
Brewers Grains 25%	4 "	.79	1.91	
		2.24	11.80	1:5.3
Corn Silage	30 "	.27	3.87	
Corn Fodder	8 "	.20	2.94	
Cow pea hay	6 "	.47	1.92	
Wheat bran	3 "	.37	1.36	
Gluten Meal	2 "	.64	1.45	
		1.89	11.54	1:6.1
Corn and Cob Meal	5 "	.22	3.32	
Wheat bran	3 "	37	1.36	
Gluten Meal	2 "	.64	1.45	
		1.23	6.13	
Corn Fodder	15 "	.38	5.60	
		1.61	11.73	1:7.2
2 lbs. More of Above Grain Mixture		.25	1.22	
		1.86	12.75	1:6.8
Corn Silage	40 "	.36	5.16	
Corn Fodder	5 "	.09	1.75	
2 pts. Wheat Bran				
3 pts. Gluten	7 "	1.40	3.92	
		1.85	10.83	1:5.9

APPENDIX TO BULLETIN No. 84.

THE FEEDING OF FARM ANIMALS.

PRINCIPLES OF ANIMAL NUTRITION; COMPOSITION AND DIGESTIBILITY OF FOODS; ACCESSORY CONSIDERATIONS IN FEEDING; SOME RATIONS FOR DIFFERENT FARM ANIMALS; COMPUTING RATIONS FOR FARM ANIMALS; TABLES SHOWING THE COMPOSITION, DIGESTIBILITY AND FERTILIZING PROPERTIES OF STOCK FOODS.

INTRODUCTION.

In presenting this appendix upon the feeding of farm animals, it is not intended to present any new facts, and the writer makes no claims for originality; but the matter is presented at this time, and in this form, because of the great interest which is being manifested in this subject, and because of the constant and increasing demand which is being made upon the Station for information along these lines. While many experiment stations have issued bulletins upon this subject, yet, the numbers which are available for distribution in this State are limited. The information set forth in the bulletins of other States and of the United States Department of Agriculture has been liberally drawn upon in the preparation of this portion of this bulletin; yet, special attention has been given to collating such facts and putting them in such shape as to make the matter particularly applicable to the food supply and climatic conditions prevailing in Maryland.

OBJECTS OF FEEDING.

The objects in feeding farm animals may be summarized under the following heads:

1. To supply the materials for growth and development.
2. To supply the material for maintaining the bodily functions and heat.
3. To supply the materials to repair waste and wear.
4. To supply materials to reproduce young.
5. To supply materials for force and energy for muscular labor.
6. To supply materials for the growth and secretion of various products.

Any food fed in excess of the requirements for the particular objects sought will be either stored in the body as a reserved force, or when conditions are such as to prevent such storage then there will be waste. From these facts it will be apparent that for the maximum utilization of food it is necessary to have a good understanding of the composition of animals and their products and the compositions and functions of food, so that they may be mutually handled for the greatest and most economical results.

COMPOSITION OF ANIMALS AND ANIMAL PRODUCTS.

The animal body and animal products are made up of a large number of substances of more or less complex compositions; but for use in preparing rations they may be considered and grouped under five heads.

1. Water.—This is one of the principal ingredients of the animal body, amounting to from forty to sixty per cent. of the weight of the live animal. This ingredient also represents a large percentage of all animal products, as, for instance, milk contains 82 to 90 per cent.

2. Ash or Mineral Matters.—These amount to from two to five per cent. of the weight of the live animal. Their presence is most evident in the bones, but they exist in small quantities in all parts of the body, and are just as essential as any other ingredient.

3. Protein.—This is a name given to an important group of substances of which white of an egg or lean meat are good examples. Protein contains about sixteen per cent. of the element nitrogen, the other three groups containing no nitrogen whatever. The organic part of the bones, the ligaments and muscles which bind together and move the bones, the skin, the internal organs, the brain, the nerves, in short the whole working machinery of the body are made up largely of protein. This group of substances is of great importance, and particular attention is necessary to supply sufficient of it in the animal food; particularly to young and growing animals and to milch cows. The casein or cheesy part of milk is largely made up of protein.

4. Fat.—This term needs no special explanation. The amount of fat in the body will vary greatly, but is seldom below six or above thirty per cent. Milk contains from three to six per cent. of fat.

5. Carbohydrates.—In animal products there is a fifth class or group of substances represented by the sugar in milk. This corresponds with the carbohydrates group in feeds.

COMPOSITION OF FEEDS.

In feeding stuffs we find the same groups of ingredients which we do in animals and animal products. The individual substances which make up these groups differ more or less from those found in the body of the animals, but in this connection these differences may be regarded as of comparatively little importance.

The following statements concerning fodder analyses may be an aid in understanding the tables. The analysis of any plant or animal substance with reference to its use as a cattle food does not go so far as to determine the percentage of every single ingredient in the material analyzed, but only aims to learn the percentage of certain classes of compounds, the members of each class having a close resemblance in composition and in nutritive effect. Thus we may have in all fodder tables serveral figures headed by the following terms: Water, crude ash, crude protein, crude fiber, nitrogen-free extractive matter (some-

times called carbohydrates), and crude fats. As these terms are in constant use in all agricultural literature, they are briefly explained, as seems necessary in order to show their relation to animal nutrition.

Water or Moisture.—This is determined by the loss of weight which takes place when the substance is dried for some time at a temperature slightly above that of boiling water. The substance remaining, after driving off all the water, is the dry or water free-substance. Water in cattle foods has no nutritive value above water that an animal drinks, but its presence often has a marked influence upon the palatability and digestibility of feeding stuffs.

Crude Ash.—This is the residue which remains after burning, and is composed of the mineral constituents of the plant. It is called crude because, as it is usually determined, it contains some charcoal, sand and carbonic acid, which do not belong to the real mineral substance of the plant. The amount of ash in plants is influenced to a marked degree by their age and conditions of growth, such as manuring, locality, etc. The mineral compounds of cattle foods fill an important place in furnishing the material for building up the bony framework of the animal.

Crude Protein.—This is a collective term, including all the nitrogenous constituents of plants, and is made up of two general classes of compounds: first the "albuminoids," which in a general way resemble (in composition and properties), lean meat or the white of an egg; second, "amides," which exist most abundantly in fodder or root crops, resemble the albuminoids in containing nitrogen, and were formerly confounded with them, but differ in being soluble in water and having a different nutritive value. The flesh, tendons, ligaments, internal organs, brain, nerves, skin, and in fact all the working machinery of the animal body, are mainly composed of albuminoids.

Crude Fibre signifies the woody portion of the plant. This is to a considerable extent digestible.

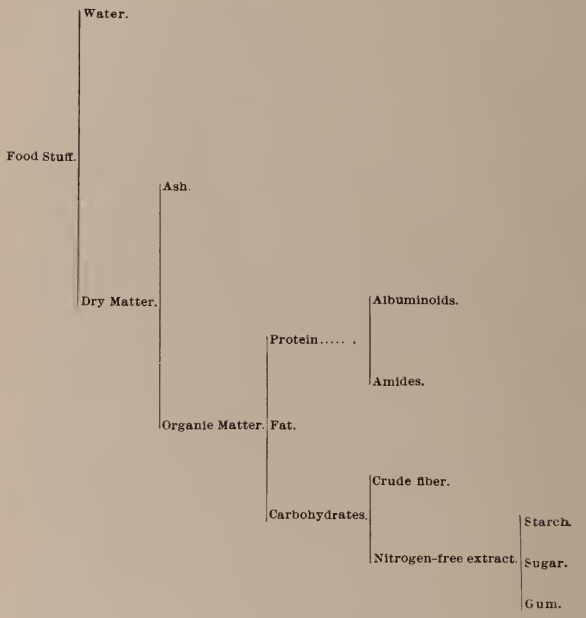
Nitrogen Free Extract.—This includes all the organic compounds of the plant containing no nitrogen except crude fat and crude fibre. The principal members of this class being starch and sugar, has caused the term carbohydrates to be sometimes used.

Crude Fat.—This includes vegetable oils and other parts which can be extracted from the plant by ether, and is a mixture of true fat, waxes and green coloring matter.

The average composition of the cattle foods commonly in use in this State are given in Table III of this appendix.

Dry Matter and Organic Matter.—Neither of these terms represent a single class of constituents or nutrients. Dry matter is what is left of a plant or food stuff after the water is driven off or subtracted, and organic matter is dry matter minus the ash.

To enable those not familiar with the subject to gain a clear idea of the parts of food stuffs and the terms representing them as used in fodder analyses the following statement is presented:



The following tabular statement may help to fix in the mind that which has been said regarding the composition of animals, animal products and feeds, and the groups into which they are divided.

Ingredients of Animals.	Ingredients of Animal Products.	Ingredients of Feeds.
1. Water.	1. Water.	1. Water.
2. Ash.	2. Ash.	2. Ash.
3. Protein.	3. Protein.	3. Protein.
4. Fat.	4. Fat.	4. Fat.
	5. Carbohydrates.	5. Carbohydrates.

DIGESTIBILITY OF FOODS.

The value of a food does not depend simply upon the total amount of the various components which it contains, but also upon the proportion of them which the animal is able to digest and assimilate.

In order to determine how much of a food is digested, it is submitted to careful digestion experiments with animals. In these tests accurate weights are kept of the amount of food consumed and excrement voided. The food and excrement are sampled and analyzed. The difference betwen the food compounds eaten and excreted will give the amount digested or assimilated. These results when calculated into percentages are termed the digestion coefficients. There have been a great many digestion experiments conducted in this country and Europe with all classes of the commoner cattle foods. These results have been compiled in tabular form and are given in Table IV of this appendix.

USES OF INGREDIENTS OF FOODS.

Having considered the composition and digestibility of different foods, the next point for consideration is as to the use the animal makes of these components.

Water.—While water is not truly a food, and might be left out of consideration, yet that which is consumed in the food and drink furnishes what is required by the animal in growth and in making various animal products.

Ash.—The ash or mineral matter of foods serves as a source of supply for the mineral ingredients of the body; under ordinary circumstances the supply of ash is amply sufficient for all bodily needs; yet, occasionally in feeding young animals or in cases where the food consists largely of grain it is desirable to add wood ashes, pure bone or precipitated chalk and phosphate of lime.

Protein.—The protein of the food is used to build up and keep in repair the working tissues of the body, which, as has been previously stated, consists very largely of protein. The growth of tissue may be an actual increase in bulk as in growing animals, or it may be simply making good the waste, as in mature animals, or it may be the growth of hair or wool, or the production of milk. For all these purposes protein is indispensable, and its place cannot be taken by any other food compound. If more protein is fed than is needed, or than can be used in tissue growth, the excess can replace fat or carbohydrates in furnishing fuel or producing fat.

Crude Fiber, Nitrogen-free Extract and Fat, or Carbohydrates and Fat.—The use of this class of substances may be conveniently considered together. They serve three purposes. 1st. They produce the heat required for keeping the animal warm. 2nd. They produce the force exerted when the animal is in motion or working. 3rd. When there is an excess of these above what is required for heat and force, it is stored in the body in the form of fat.

While fat and carbohydrates have substantially the same use in the body, yet, a given weight of fat is worth more than that same weight of carbohydrates, from the fact that one pound of fat will produce about two and one-fourth times as much heat as a pound of carbohydrates; hence, is two and one-fourth times as valuable. The same relation holds betwen the two as force producers, and probably as fat producers. For these reasons the fat has been multiplied by two and one-fourth, and united with the carbohydrates in Table V.

The office or functions performed by the food nutrients may be summarized as follows:

Water in Food and Drink.—Furnishes the water used in forming the animal body and products.

Ash or Mineral Matter.—Principally used in forming bone, but also a very small amount is consumed by all other parts.

Fat and Carbohydrates (Starch, Sugar, Gums, Etc., Nitrogen-free Extract).—Are used as fuel for heat and force, or converted into fats and stored in the body.

Protein is the basis of blood, lean meat, tendons, ligaments, sinews, hair, skin and an essential component of milk. If not used for these may be converted into fat or used as fuel.

NUTRITIVE RATIO.

The different foods, as will be seen in the table of digestible nutrients, vary considerably in their composition and in the relative amounts of the protein and carbohydrates. Nutritive ratio is a term used to designate the proportion of the protein (nitrogenous) to the carbohydrates (non-nitrogenous or carbonaceous) food constituents, or, in other words, it is the ratio of the digestible protein to the sum of all the remaining nutrients in the food.

The ratio is said to be wide when there is relatively much of the carbohydrates as compared to the protein, as for example in corn fodder. When there is a closer relation between the two classes of nutrients, as in the case of alfalfa hay, wheat bran, cotton seed meal, gluten meal, etc., the ratio is said to be narrow.

AMOUNTS OF PROTEIN NEEDED FOR DIFFERENT PURPOSES.

It is evident from what has been said that all classes of animals do not need the same amount of the different food compounds and that the nutritive ratio (proportion of protein to carbohydrates) should vary according to the purposes of feeding. If tissues are to be built or repaired, that is if the feed is to produce growth, milk or wool, etc., there should be sufficient protein fed to furnish the raw materials for this production. If, on the other hand, the object is to produce fat or work, then just sufficient protein will be needed to keep the tissues in

repair, and the bulk of the food should consist of carbohydrates and fat. The feeds for ordinary farm animals may be grouped as follows:

Requiring relatively more protein or narrow nutritive ratio.	Requiring relatively less protein or wider nutritive ratio.
Growth.	Maintenance.
Milk production.	Fattening.
Wool production.	Work.

Feeding Standards.

The statements made above are not sufficiently definite for the purpose of those who desire to have their animals do their best and at the same time feed economically. It is necessary not only to know that for some purposes more protein must be applied, and in others less—but it is also desirable to know what amounts and proportions of protein and carbohydrates, (that is what nutritive ratio) is best adapted for the particular case in hand.

Unfortunately, all these questions cannot be answered in every case; however, the results of experiments and of practical experience have been compiled and condensed into a shape called "feeding standards" which serves as a general guide.

Such standards are not receipts, but statements of experience, which should be applicable to average conditions. It shows what has given good results in the hands of some feeders but it may not be exactly adapted to the particular conditions of every user, and should be modified according to circumstances.

Feeding standards are expressed in the quantities of the food nutrients needed for a given purpose per 1,000 pounds of live weight of the animal; in order that the standard may admit of a wide and general application as possible with the different foods and animals at hand. In table I of the appendix are given a number of feeding standards for various purposes. Most of these are based upon the work of German investigations.

Use of Feeding Standards.

The feeding standards as set forth in Table I page 170, are only intended to serve as a guide in making mixtures of feeds so that a ration may be prepared which will furnish approximately the amounts and proportion of the digestible nutrients desirable in feeding for special purposes. When using such a mixture of feeds, the feeder will be following the methods which have been recorded as giving good results; but would not necessarily be using the best ration which could be used in his particular case. Nevertheless, the following of these standards would insure the feeder much more satisfactory results than are obtained from the common haphazard feeding, based upon the feeds which happen to be at hand or can be purchased in the markets at the lowest price.

Accessory Considerations in Feeding.

The young and inexperienced stock feeder must remember that there are many points to be considered and observed in connection with the feeding of animals beyond the facts set forth in the preceding pages. It will be found that there is more to be done in order to insure success than simply to see that the ration made up contains the theoretical amounts of the several food constituents. In order that an animal will give the proper returns for the food constituents fed, it will be necessary to make sure that the ration possesses all of the qualities of flavor, succulency and so forth, which go to make it appetizing and palatable. Then, too, the animal must be placed in congenial surroundings, having light, well ventilated and comfortable quarters and, above all, be treated with extreme kindness and gentleness. The young stockman will do well to mix some judgment, good common sense, and the best of his individuality with his rations, and remember that there is much truth in the principles involved in the old German adage, "the eye of the master fattens his cattle."

The stockman whose only training has been in the school of experience often holds in light regard the results of experiments and the principles set forth and expressed by the "well balanced ration;" but generally the successful feeder in practice has been a close observer and worked out through experience that which closely agrees to the teachings based upon the compositions of feeds and of animals and animal products.

Water.

An abundant supply of pure, palatable water, summer and winter, easily obtained, is necessary in order to give the animals the most comfort and enable them to fully utilize their food and produce all of which they are capable. There is a notion that any kind of water is good enough for stock, but such is a great mistake. Stock should have as good water as people. Unless the water is good, the animals will not drink all that is good for them, and the drinking of tainted and impure water is apt to cause disease in the animal and directly impair the quality of milk and butter. In winter animals are often required to drink ice water from the creek and they generally will not drink as much as is needed because they dread the chill.

None of our animals suffer so much because of insufficient and improper watering as horses. Horses should be watered oftener and not so much at once, and they should be watered before feeding, and not immediately after. There are many devices on the market by which a supply of water may be constantly kept in the stable in such a way as animals can have access to it, and tests of such apparatus have shown them to give valuable returns.

Salt.

A supply of salt which is constantly available to animals is desirable. Salt stimulates the appetite, assists digestion and assimilation. Salting once or twice a week, as is often practiced, is not sufficient. Mixing salt with the food is not best, as by this method sometimes more salt is given than is good for the animal.

Where animals have not had free access to salt, it is best to work them up to it gradually, as animals which have not had a full supply are apt to overeat it first, and an overdose acts like poison, producing scouring and otherwise interferes with digestion.

It is a good plan to keep rock salt in such places as the animals can get it at will. Loose salt may be used, but it is not so convenient and more likely to be wasted.

Succulency.

When animals are on pasture it is well known that their digestive organs are in good order, and no doubt that results which are obtained in a large measure are due to the succulency of the food. The value of the pasture over the same food dry rests in this fact.

Succulent feeds have the advantages that they are appetizing and they keep the system in a healthy condition.

Of course, it is not possible to have pasture the year round, but good silage and roots serve as good substitutes.

When neither silage nor roots can be obtained much can be done towards keeping the digestive system in good order by combining foods of laxative and constipating tendencies. The following lists give the general effects which our common feeds have when fed in limited quantity.

Laxative, or loosening feeds.		Constipating Feeds.
Wheat Bran,	Cow Pea Hay,	Corn Grain,
Linseed Meal,	Wheat,	Corn Fodder,
Gluten Meal,	Sorghum Hay,	Cottonseed Meal,
Silage,	Oats,	Timothy Hay,
Roots,	Barley,	Straw.
Clover Hay,	Rye,	

Variety.

Animals, like people, crave a variety of food, and do best when they have it. While a variety is desirable, yet, it is best to give the variety by feeding a mixture at each meal rather than to feed different things at different times. Animals do not take kindly to sudden changes of food, and will not do well when fed irregularly in this respect. Mixtures of a number of feeds give flavor and make a more appetizing ration, and animals will eat more and do better than when fed on only one or two, even though the amounts of protein and carbohydrates may be the same in each case.

In attempting to give a variety of feeds do not follow a practice which is very common, and that is of giving a feed once or twice each week of a specially rich food. This is a bad practice on two accounts. 1st. The animal cannot properly utilize the excess of protein which would be furnished in the occasional feeds, and there would be loss, and, 2nd. The animal will do much better, and eat better if these rich foods were mixed with the general ration, so that they would get it distributed through the seven days rather than get it all on one day.

Appetizing Rations.

There has been considerably said already on the importance of making rations appetizing and suggestions made which would contribute to that end. Water makes a food taste better, makes it more enjoyable, and increases its value. Early cut hay, for instance, is best not only because it contains more protein than that cut late, but because its aroma and flavor make it more palatable.

It is not well to feed animals too much at one time, as they pick out the most desirable parts first and mess the other over,which detracts from its palatability, and either entails loss of food or products, whereas feeding in different ways and less at a time would give better results from the same food. Mangers, feed troughs and racks should be kept clean both from a sanitary standpoint and in order to make the foods more appetizing, and to have more of it eaten, and thus get better results.

Shelter, Comfort and Kindness.

These are three factors in the feeding of animals that are as much neglected as any other, and, in fact, many people have come to study the needs for making a "well-balanced ration," and have entirely ignored these essentials. The attention to shelter, comfort and kindness for animals will save many a pound of food, and do much toward increasing the products obtained, no matter whether the returns are to be work performed, milk and butter, or meat products.

Winter quarters for animals should be warm and dry, and should be furnished with plenty of pure air and good sunlight. Stables should be well ventilated, but without being drafty. There is entirely too little attention paid to having the stable well lighted, especially to having such arrangements as to admit of a flood of sunlight. Sunlight is an effective destroyer of disease germs.

Whatever adds to the comfort of animals increases their ability to properly utilize the food, and will enable them to give better returns for that which is being consumed. Kindness is an efficient aid in making animals more productive, and it costs nothing. Abuse and excitement will interfere with digestion, and cause a loss of food and product. Kindness and petting makes animals contented, and puts their nervous systems in a condition to properly utilize food, and to return their fullest measure of profit.

Feeding Cows.

The increase of the dairy interests of this State with the rapid rise in the price of feeds during the past five years has made the feeding of milch cows a very important subject. No animal responds so promptly and profitably to careful feeding. The cow, owing to the construction of the digestive system, is able to consume large quantities of coarse foods. Because cows can utilize this roughage they are generally imposed upon, and expected, in many instances, to subsist upon it, and at the same time give good flows of milk; yet, they need finer and richer foods, and give profitable returns for it. The returns and improvements that may be worked by liberal feeding and good care of cows is well brought out in the discussion in Bulletin No. 69 of this Station.

In feeding cows it must be remembered that they need more than sufficient for maintenance, for they require food for furnishing nutriment to the fetus, and the materials which are necessary in making milk. It will be noted that in the Table 1, giving the feeding standards, that there are two standards for milch cows, viz., the "German Standard" and the "Wisconsin Standard." The German Standard is one that has been worked out by German investigators, and is based upon the food requirements for maintenance plus that which is necessary in order to furnish the constituents required for a good average flow of milk. The Wisconsin Standard is not a standard, in the true sense, as it is not based upon actual experiments, but simply the results of calculations based upon the compilation of a great number of rations that are being fed by successful practical dairymen.

Notwithstanding these facts there seems good reason to believe that the Wisconsin Standard is more suitable to the conditions under which the average dairyman of this State is laboring than the German Standard. The reasons for this are as follows: 1st.—A comparison of the nutritive ratio of the German Standard with the nutritive ratio of the good June pasture made up largely of blue grass (sometimes called green grass or June grass) with some white clover show them to be almost identical. Now, it is well known that cows as a rule do their best when on a good May or June pasture. Now, this being true, it is but reasonable to suppose that if the nutritive ratio of 1:5.4 is about right for June weather conditions that with winter weather conditions there will be more need to supply the animal with a larger amount of the heat-producing elements, and thus call for a wider ratio, and probably that as expressed by the so-called Wisconsin Standard is about right. The second consideration which might account for some difference in the ratio requirements of this country as compared to German ratio is the fact that average milk in this country is higher in total solids and noticeably richer in fat, all of which call for relatively more carbohydrates. The following sample rations may serve the purpose of some, as they are made up from feeds common to many parts of the State. They will also serve as further illustrations of how rations are calculated.

The Dairy Calf.

In connection with the feeding of cows, it would be well to remember that much can be done towards producing a good cow by feeding her properly when a calf. Calves which are being raised for cows should be well fed, but in such a way as to keep them growing without getting fat. Many a good cow has been spoiled by developing the beef tendencies when young. The principal point is to feed a highly nitrogenous ration and not overfeed. Sometimes calves on pastures will get very fat in appearance, but experience has shown that pasture fat in a calf or heifer will work off and not injure them permanently like the fat made by overfeeding in the stable with grain, particularly corn.

Feeding for Beef.

In feeding for beef very different rules may be used as a guide from feeding for milk. Even with the calf, the object is to produce as much fat as possible at the same time making growth. If possible, the calf fat with which it is born should never be lost, but continually added to. This means forcing with plenty of muscle and fat-making foods.

In feeding for beef much attention should be paid to the age of the animal and period of fattening, as illustrated in the standard, than is commonly practiced. The beef feeders of this State are very generally following the old-time customs, and they are not so nearly progressive and wide-awake to their business as their brothers who are dairymen.

The character of stock and general condition are so variable that it does not seem desirable to print any sample ration in this connection, but they can be calculated upon the same principles as those for cows; but feeders should select and vary the standard with different periods of fattening.

Horse Feeding.

This Station has published a brief general discussion of the question of horse feeding together with the results of some experiments on this subject in Bulletin No. 51. This bulletin is still available, and all who are specially interested can procure copies upon application.

Swine Feeding.

The general principles involved in feeding for the production of pork are discussed in connection with the results of some experiments conducted upon this subject in Bulletin No. 63 of this Station.

In feeding pigs intended for breeding purposes, of course, different methods should be followed from those for the production of pork. In the main there should be made the same difference as have been suggested between feeding calves and cows for milk and feeding for beef. Breeding pigs should be fed largely on a vegetable and bulky diet rather than on a concentrated grain diet.

Sheep Feeding.

The same principles are involved in the feeding of sheep as in feeding other classes of animals, and special attention should be paid to making a difference in feeding those sheep which are intended for breeding purposes and those which are to go for meat. It is particularly desirable that sheep should have some succulent food at all times of the year. Roots and silage aid in this respect very materially for the winter months.

Poultry Feeding.

The proper feeding of poultry should be conducted upon the same lines as is that of other stock. The feeding of laying hens is just as important as the feeding of a cow, and the hen will give equally as quick and even more remunerative returns. In fact, a grain ration that is suited for a cow serves very well for hens, but of course should be supplemented with grit, oyster shells, bone, etc., which are specially needed by fowls. For a special treatise on the feed and care of chickens write to the U. S. Department of Agriculture for Farmers' Bulletin No. 41.

Computation of Rations.

The calculation of a stock ration which will approximate that which is set down in the table of standards or in other words, what is known as "well balanced" for a given purpose, is not an easy matter; yet, it is not as difficult as many think. Unfortunately, no definite rule can be given for making the computation, yet, from a general inspection of the quality of the foods as set down in Table 5, giving the digestible nutrients and paying particular attention to the nutritive ratios as given in the last column of figures, some idea can be gained as to the adaptability of the different foods which could be used in a mixture so as to give a ration of the desired standard. A little study of the qualities of different foods so as to become familiar with their nutritive values will enable any one to soon be able to formulate rations that will approximate the standard. In making up rations it is always well in the original calculations to use the amounts which would be required for one ration, or twenty-four hours' feeding, according to standards, but when it comes to the actual practice of mixing the ration do not weigh or measure out the quantities of each food for each animal daily, but mix up a ton or more at a time, and then feed from this mixture, varying the amounts with the individual animal according to size, appetite and so forth. This will reduce the amount of labor involved to a minimum, and approximate the standard and requirement of each individual as well as though the rations were weighed and mixed each day for each animal. If this system was practiced it would remove the difficulty which seems to arise in the minds of many when the question of a well-balanced ration is first presented, and it would make good feeding almost as simple as the common practice.

How to Use Tables in Compounding Rations.

The method of using the Table No. 5 showing the amounts of digestible nutrients in different foods in order to calculate a ration for a given purpose is best shown by using an example.

Suppose a dairyman had corn silage made from corn which would have husked ten barrels per acre, and clover hay, and desired to purchase some grain products, so as to furnish the materials requisite for making a well-balanced ration. At first, assume the cows to weigh 1,000 pounds, and that the standard selected is that known as the Wisconsin dairy ration. The first thing to do is to put down the amounts of the silage and hay that the cows will eat, and the nutrients which they will furnish. The amounts will be seen by turning to Table 5, on page 185, giving the nutrients in the silage, and on page 187, that in the hay.

	Quantity. lbs.	Dry Matter. lbs.	Protein. lbs.	Carbohydrates. lbs.
Corn Silage	40	10.5	0.48	7.10
Clover Hay	5	4.3	0.34	1.98
	45	14.8	0.82	9.08

Nutritive ratio 1 :11.5.

From the above it will be seen that the silage and hay would furnish a ration which would need to be supplemented by about ten pounds of dry matter, 1.4 pounds protein and 5.8 pounds carbohydrates.

Now, suppose that wheat middlings and gluten meal were the most convenient to procure on the market, and it was desired to supplement the silage and hay. This may be done as follows:

	Quantity. lbs.	Dry Matter. lbs.	Protein. lbs.	Carbohydrates. plus fat, lbs.
Corn Silage	40	10.5	0.48	7.10
Clover Hay	5	4.3	0.34	1.98
Wheat Middlings	9	7.9	1.15	5.46
Gluten Meal	1	0.9	.32	.45
Total in Ration..		23.6	2.29	14.99
Standard		24.5	2.2	14.9

Nutritive Ratio of Ration 1 :6.6.

Nutritive Ratio of Standard 1 :6.8.

The above would be sufficiently close for all practical purposes.

Now, instead of weighing out the nine pounds of middlings and one pound of gluten meal for each cow each time, and having to vary the amount with the size, appetite, etc. of each cow, the practical plan would be to weigh out nine hundred pounds of the middlings, and one hundred pounds of gluten meal and mix them thoroughly and

then they are ready for feeding as needed, and the practical feeder can vary the amounts reasonably close, measuring so as to meet the requirements of each cow. The same is true of the silage and hay. Other sample rations will be found under the experiments reported in this bulletin, and in the parts referring to the feeding of special kinds of animals, and under the discussion of the question of the home production of protein.

The Relative Value of Foods.

In making up rations the question of the value of different foods is constantly arising, and is one that should be given due consideration for it is not only desirable to procure a ration that will be balanced, but the aim should be to have it cost as little as possible.

With most farmers, the aim in purchasing feed is generally to get the protein, and if that is the only point involved the feed should be used that furnishes that constituent cheapest; yet, even under such circumstances some consideration must be given to the other food constituents which are supplied, and even the manurial value of a feed should be taken under consideration.

By calculating the total amount of digestible nutrients furnished by one ton of feed from the data given in Table 5, and dividing that into the selling price of one ton, the result will be the cost of one pound of nutrient. This will serve in most cases as a good basis upon which to buy. As far as has been determined, digestible protein, starch, etc., have practically the same feeding value, no matter from what sources they may be derived.

The Fertilizing or Manurial Value of Feeds.

All feeds contain a certain amount of the three valuable ingredients which give commercial fertilizers their value namely, phosphoric acid, potash and nitrogen. In feeding, most of these are recovered in the manure of the animals fed. Hence, it is important to consider this phase of the value of feeds, and to consider it in purchasing and selling feeds; for on the one hand fertility is being purchased, and on the other hand fertility is being sold. In considering the profits of feeding operations due consideration should always be paid to the resulting manure and its value in maintaining the fertility of the farm.

The fertilizing constituents in feeds are given in Table 6, together with the approximate value per ton calculated on the same basis of commercial fertilizers. It is doubtful if much of the plant food in a food-stuff is as available to crops as the plant food in average commercial fertilizers; hence, not quite so valuable, pound for pound. Yet, when it is considered that the food-stuff furnishes considerable organic matter, which is of value to land, this really overbalances any deficiency in value which may be due to the essential plant foods being less available.

TABLE I.

Feeding Standards.

A—Per day and 1,000 pounds live weight.*

	Dry Matter, lbs.	Digestible.			Nutritive Ratio.
		Protein, lbs.	Carbohydrates and fat, lbs.	Total, lbs.	
Oxen at rest in stall	17.5	0.7	8.3	9.0	1:11.9
Wool sheep, coarser breeds	20.0	1.2	10.8	12.0	1: 9.0
Wool sheep, finer breeds	22.5	1.5	12.0	13.5	1: 8.0
Oxen moderately worked	24.0	1.6	12.0	13.6	1: 7.5
Oxen heavily worked	26.0	2.4	14.3	16.7	1: 6.0
Horses lightly worked	20.0	1.5	10.4	11.9	1: 6.9
Horses moderately worked	21.0	1.7	11.8	13.5	1: 6.9
Horses heavily worked	23.0	2.3	14.3	16.6	1: 6.2
Milk cows, Wolff's standard	24.0	2.5	13.4	15.9	1: 5.4
Milk cows, Wisconsin standard	24.5	2.2	14.9	17.1	1: 6.8
Fattening oxen, preliminary period	27.0	2.5	16.1	18.6	1: 6.4
Fattening oxen, main period	26.0	3.0	16.4	19.4	1: 5.5
Fattening oxen, finishing period	25.0	2.7	16.2	18.9	1: 6.0
Fattening sheep, preliminary period	26.0	3.0	16.3	19.3	1: 5.4
Fattening sheep, main period	25.0	3.5	15.8	19.3	1: 4.5
Fattening swine, preliminary period	36.0	5.0	27.5	32.5	1: 5.5
Fattening swine, main period	31.0	4.0	24.0	28.0	1: 6.0
Fattening swine, finishing period	23.5	2.7	17.5	20.2	1: 6.5
Growing Cattle: Av. Live Weight					
Age. Months. per head.					
2.... 3.....150 lbs.....	22.0	4.0	18.3	22.3	1: 4.6
3.... 6.....300 lbs.....	23.4	3.2	15.8	19.0	1: 4.9
6....12.....500 lbs.....	24.0	2.5	14.9	17.4	1: 6.0
12....18.....700 lbs.....	24.0	2.0	13.9	15.9	1: 7.0
18....24.....850 lbs.....	24.0	1.6	12.7	14.3	1: 8.0
Growing sheep:					
6.... 6..... 56 lbs.....	28.0	3.2	17.4	20.6	1: 5.4
6.... 8..... 67 lbs.....	25.0	2.7	14.7	17.4	1: 5.4
8....11..... 75 lbs.....	23.0	2.1	12.5	14.6	1: 6.0
11....15..... 82 lbs.....	22.5	1.7	11.8	13.5	1: 7.0
15....20..... 85 lbs.....	22.0	1.4	11.1	12.5	1: 8.0
Growing fat pigs:					
2.... 3..... 50 lbs.....	42.0	7.5	30.0	37.5	1: 4.0
3.... 5.....100 lbs.....	34.0	5.0	25.0	30.0	1: 5.0
5.... 6.....125 lbs.....	31.5	4.3	23.7	28.0	1: 5.5
6.... 8.....170 lbs.....	27.0	3.4	20.4	23.8	1: 6.0
8....12.....250 lbs.....	21.0	2.5	16.2	18.7	1: 6.5

*The following rations are calculated for 1,000 lbs. live weight at the beginning of the fattening.

B—Per day and head.

	Dry Matter, lbs.	Digestible.			Nutritive Ratio.
		Protein, lbs.	Carbohydrates and fat, lbs.	Total, lbs.	
Growing cattle:					
2.... 3.....150 lbs.....	3.3	0.6	2.8	3.4	1: 4.6
3.... 6.....300 lbs.....	7.0	1.0	4.9	5.9	1: 4.9
6....12.....500 lbs.....	12.0	1.3	7.5	8.8	1: 6.0
12....18.....700 lbs.....	16.8	1.4	9.7	11.1	1: 7.0
18....24.....850 lbs.....	20.4	1.4	11.1	12.5	1: 8.0
Growing sheep:					
5.... 6..... 56 lbs.....	1.6	0.18	0.974	1.154	1: 5.4
6.... 8..... 67 lbs.....	1.7	0.18	0.981	1.161	1: 5.4
8....11..... 75 lbs.....	1.7	0.16	0.953	1.113	1: 6.0
11....15..... 82 lbs.....	1.8	0.14	0.975	1.115	1: 7.0
15....20..... 85 lbs.....	1.9	0.12	0.955	1.075	1: 8.0
Growing fat swine:					
2.... 3..... 50 lbs.....	2.1	0.38	1.50	1.88	1: 4.0
3.... 5.....100 lbs.....	3.4	0.50	2.50	3.00	1: 5.0
5.... 6.....125 lbs.....	3.9	0.54	2.96	3.50	1: 5.5
6.... 8.....170 lbs.....	4.6	0.58	3.47	4.05	1: 6.0
8....12.....250 lbs.....	5.2	0.62	4.05	4.67	1: 6.5

TABLE II.

Percentage Composition of Live Animals.

	Ox.				Sheep.					Swine	
	Well-fed.	Half fat.	Fat,	Fat calf.	Lean.	Well-fed.	Half-fat.	Fat.	Very fat.	Well-fed.	Fat.
	Per ct.	Per ct.	Per ct.	Per ct.	per et.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Water	54.3	50.2	43.6	60.1	56.6	53.7	50.7	44.8	39.0	53.9	42.0
Ash	4.0	4.4	3.9	4.5	3.4	3.3	3.2	2.9	2.8	2.7	1.8
Fat	7.1	14.9	26.8	13.1	8.6	13.2	18.3	28.1	37.2	22.5	40.2
Protein	15.8	15.5	13.7	15.3	15.4	14.8	13.8	12.2	11.0	13.9	11.0
Contents of Stomach and Intestine	18.0	15.0	12.0	7.0	16.0	15.0	14.0	12.0	10.0	7.0	5.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE III.

Average Composition of American Feeding Stuffs.

The figures in the following table, unless otherwise noted, have been taken from Bulletin No. 11, Office of Experiment Stations; Farmers' Bulletin No. 22, U. S. Department of Agriculture; Henry's Feeds and Feeding, Bulletin No. 81, Vermont Agricultural Experiment Station, and Bulletin No. 166, New York State Agricultural Experiment Station.

The percentages given represent averages from which there are material variations. These variations are mostly due to differences in the water content, the influence of localty, and of the stage of growth and the changes brought about by the methods and conditions of curing. They are not as large and important with grains as with the fodders.

*Corn Fodder.	Number of Analysis.	Percentage Composition.					
		Water.	Ash.	Protein.	Crude Fiber.	Nitrogen Free Extract.	Fat.
Green Fodder.							
Flint varieties	40	79.8	1.1	2.0	4.3	12.1	.7
Flint varieties cut after kernels had glazed	10	77.1	1.1	2.1	4.3	14.6	.8
Dent varieties	63	79.0	1.2	1.7	5.6	12.0	.5
Dent varieties cut after kernels had glazed	7	75.4	1.5	2.0	6.7	15.5	.9
Sweet varieties	21	79.1	1.3	1.9	4.4	12.8	.5
All varieties	126	79.3	1.2	1.8	5.0	12.2	.5
Leaves and husks, cut green	4	66.2	2.9	2.1	8.7	19.0	1.1
Stripped stalks, cut green	4	76.1	.7	.5	7.3	14.9	.5
Sorghum fodder	11	79.4	1.1	1.3	6.1	11.6	.5
Rye fodder	7	76.6	1.8	2.6	11.6	6.8	.6
Barley fodder	1	79.0	1.8	2.7	7.9	8.0	.6
Oat fodder	6	62.2	2.5	3.4	11.2	19.3	1.4
Pasture grass		80.0	2.0	3.5	4.0	9.7	.8
Redtop†, in bloom	5	65.3	2.3	2.8	11.0	17.7	.9
Tall oat grass‡, in bloom	3	69.5	2.0	2.4	9.4	15.8	.9
Ochard grass, in bloom	4	73.0	2.0	2.6	8.2	13.3	.9
Meadow fescue, in bloom	4	69.9	1.8	2.4	10.8	14.3	.8
Italian rye grass, coming into bloom	24	73.2	2.5	3.1	6.8	13.3	1.3
Timothy§, at different stages	56	61.6	2.1	3.1	11.8	20.2	1.2
Kentucky blue grass*, at different stages	18	65.1	2.8	4.1	9.1	17.6	1.3
Hungarian grass	14	71.1	1.7	3.1	9.2	14.2	.7
Japanese millet	12	75.0	1.5	2.1	7.8	13.1	.5
Red clover, at different stages	43	70.8	2.1	4.4	8.1	13.5	1.1
Alsike clover+, in bloom	4	74.8	2.0	3.9	7.4	11.0	.9
Crimson clover	3	80.9	1.7	3.1	5.2	8.4	.7
Alfalfa‖, at different stages	23	71.8	2.7	4.8	7.4	12.3	1.0
Serradella, at differ'nt stages	9	79.5	3.2	2.7	5.4	8.6	.7
Cow-pea	10	83.6	1.7	2.4	4.8	7.1	.4
Soja bean	27	75.1	2.6	4.0	6.7	10.6	1.0
Horse bean	2	84.2	1.2	2.8	4.9	6.5	0.4
Flat pea (Lathyrus sylvestris	2	66.7	2.9	8.7	7.9	12.2	1.6
Rape	2	84.5	2.0	2.3	2.6	8.4	0.5
Winter vetch¶	4	74.4	2.4	4.4	7.0	11.1	0.7

*Corn fodder is the entire plant, usually a thickly planted crop, Corn stover is what left after the ears are harvested

†Herd's grass of Pennsylvania.

‡Meadow Oat Grass.

§Herd's grass of New England and New York.

*June Grass, or Green Grass.

+Swedish Clover.

‖Lucurne.

¶Pa. Expt. Rept. 1887—p 140 Average.

TABLE III.—Continued.

	Number of Analysis.	Percentage Composition.					
		Water.	Ash.	Protein.	Crude Fiber.	Nitrogen Free Extract.	Fat.
Silage.							
Corn silage, all analyses.....	99	..79.1	1.4	1.7	6.0	11.0	0.8
Corn silage, kernels glazing	49	75.7	1.6	2.2	6.5	15.1	0.9
Corn cannery refuse, husks+	1	83.8	0.6	1.4	5.2	7.9	1.1
Corn cannery refuse, cobs+.	1	74.1	0.5	1.5	7.9	14.3	1.7
Sorghum silage	6	76.1	1.1	.8	6.4	15.3	0.3
Red clover silage.....	5	72.0	2.6	4.2	8.4	11.6	1.2
Soja bean silage.....	1	74.2	2.8	4.1	9.7	6.9	2.2
Cow-pea vine silage.....	2	79.3	2.9	2.7	6.0	7.6	1.5
Field-pea vine silage.....	1	50.1	3.5	5.9	13.0	26.0	1.6
Pea cannery refuse+.....	1	76.8	1.3	2.8	6.5	11.3	1.3
Silage of mixture of cow-pea vines and soja bean vines	1	69.8	4.5	3.8	9.5	11.1	1.3
Millet and soja bean.....	9	79.0	2.8	2.8	7.2	7.2	1.0
Corn and soja bean.....	4	76.0	2.4	2.5	7.2	11.1	0.8
Rye	1	80.8	1.6	2.4	5.8	9.2	0.3
Apple pomace	1	85.0	.6	1.2	3.3	8.8	1.1
Hay and dry coarse fodder.							
Corn fodder*, field cured....	35	42.2	2.7	4.5	14.3	34.7	1.6
Corn leaves, field cured.....	17	36.0	5.5	6.0	21.4	35.7	1.4
Corn husks, field cured.....	16	50.9	1.8	2.5	15.8	28.3	0.7
Corn stalks, field cured.....	15	68.4	1.2	1.9	11.0	17.0	0.5
Corn fodder, butts+1.....	1	46.7	2.6	1.8	20.4	27.4	1.1
Corn fodder, tops+2.....	1	15.9	6.3	4.6	28.6	42.4	2.2
Corn fodder, new corn product†	6	9.2	4.0	6.4	28.7	48.9	2.8
Corn stover†, field cured....	60	40.5	3.4	3.8	19.7	31.5	1.1
Hay from barley, cut in milk	1	15.0	4.2	8.8	24.7	44.9	2.4
Oat, cut in milk.....	1	15.	5.2	9.3	29.2	39.0	2.3
Redtop‡, cut at diff'r't stages	9	8.9	5.2	7.9	28.6	47.5	1.9
Redtop, cut in bloom.....	3	8.7	4.9	8.0	29.9	46.4	2.1
Orchard grass	10	9.9	6.0	8.1	32.4	41.0	2.6
Timothy§, all analyses.....	68	13.2	4.4	5.9	29.0	45.0	2.5
Timothy, cut in full bloom..	12	15.	4.5	6.0	29.6	41.9	3.0
Timothy, cut soon after bloom	11	14.2	4.4	5.7	28.1	44.6	3.0
Timothy, cut when nearly ripe	12	14.1	3.9	5.0	31.1	43.7	2.2
Kentucky blue grass.....	10	21.2	6.3	7.8	23.0	37.8	3.9
Cut when seed was in milk..	4	24.4	7.0	6.3	24.5	34.2	3.6
Cut when seed was ripe.....	4	27.8	6.4	5.8	23.8	33.2	3.0

+ Analyses made at the Maryland Experiment Station.
+1 Portion below the ear with husk and blades removed.
+2 Portion of stalk and blades above the ear.
* Entire plant
† What is left after the ears are harvested.
‡ Herd's grass of Pennsylvania.
§ Herd's grass of New England and N. Y.

TABLE III.—Continued.

	Number of Analysis.	Percentage Composition.					
		Water.	Ash.	Protein	Crude Fiber.	Nitrogen Free Extract.	Fat.
Hay and Dry Coarse Fodder—Continued.							
Hungarian grass	13	7.7	6.0	7.5	27.7	49.0	2.1
Meadow fescue	9	20.0	6.8	7.0	25.9	38.4	2.7
Italian rye grass	4	8.5	6.9	7.5	30.5	45.0	1.7
Perennial rye grass	4	14.0	7.9	10.1	25.4	40.5	1.7
Mixed grasses	126	15.2	5.5	7.4	27.2	42.1	2.5
Rowen (mixed)*	23	16.6	6.8	11.6	22.5	39.4	3.1
Mixed grasses and clovers	17	12.9	5.5	10.1	27.6	41.3	2.6
Swamp hay	8	11.6	6.7	7.2	26.6	45.9	2.0
Salt marsh hay	10	10.4	7.7	5.5	30.0	44.1	2.4
Hay from—							
Red clover	38	15.3	6.2	12.3	24.8	38.1	3.3
Red clover in bloom	6	20.8	6.6	12.4	21.9	33.8	4.5
Alsike clover	9	9.7	8.3	12.8	25.6	40.7	2.9
White clover	7	9.7	8.3	15.7	24.1	39.3	2.9
Crimson clover	7	9.6	8.6	15.2	27.2	36.6	2.8
Japan clover	2	11.0	8.5	13.8	24.0	39.0	3.7
Vetch	5	11.3	7.9	17.0	25.4	36.1	2.3
Serradella	3	9.2	7.2	15.2	21.6	44.2	2.6
Alfalfa†	21	8.4	7.4	14.3	25.0	42.7	2.2
Cow Pea	8	10.7	7.5	16.6	20.1	42.2	2.2
Soja bean	6	11.3	7.2	15.4	22.3	38.6	5.2
Flat pea (lathyrus sylvestris	5	8.4	7.9	22.9	26.2	31.4	3.2
Peanut vines (without nuts)	6	7.6	10.8	10.7	23.6	42.7	4.6
Pea vines	1	15.0	6.7	13.7	24.7	37.6	2.3
Soja-bean straw	4	10.1	5.8	4.5	40.4	37.4	1.7
Horse-bean straw	1	9.2	8.7	8.8	37.6	34.3	1.4
Wheat straw	7	9.6	4.2	3.4	38.1	43.4	1.3
Rye straw	7	7.1	3.2	3.0	38.9	46.6	1.2
Oat straw	12	9.2	5.1	4.0	37.0	42.4	2.3
Buckwheat straw	3	9.9	5.5	5.2	43.0	35.1	1.3
Roots and Tubers.							
Potatoes	12	78.9	1.0	2.1	.6	17.3	.1
Sweet potatoes	6	71.1	1.0	1.5	1.3	24.7	.4
Red beets	9	88.5	1.0	1.5	.9	8.0	.1
Sugar beets	19	86.5	.9	1.8	.9	9.8	.1
Mangel-wurzels	9	90.9	1.1	1.4	.9	5.5	.2
Turnips	3	90.5	.8	1.1	1.2	6.2	.2
Rutabagas	4	88.6	1.2	1.2	1.3	7.5	.2
Carrots	8	88.6	1.0	1.1	1.3	7.6	.4
Artichokes	2	79.5	1.0	2.6	.8	15.9	.2
Grains and Other Seeds.							
Corn kernel—							
Dent, all analyses	86	10.6	1.5	10.3	2.2	70.4	5.0
Flint, all analyses	68	11.3	1.4	10.5	1.7	70.1	5.0

*Second Cut.
†Lucerne.

TABLE III.—Continued.

	Number of Analysis.	Percentage Composition.					
		Water.	Ash.	Protein.	Crude Fiber.	Nitrogen Free Extract.	Fat.
Grains and Other Seeds—Continued.							
Sweet, all analyses	26	8.8	1.9	11.6	2.8	66.8	8.1
Pop varieties	4	10.7	1.5	11.2	1.8	69.6	5.2
Soft varieties	5	9.3	1.6	11.4	2.0	70.2	5.5
All varieties and analyses	208	10.9	1.5	10.5	2.1	69.6	5.4
Sorghum seed	10	12.8	2.1	9.1	2.6	69.8	3.6
Barley	10	10.9	2.4	12.4	2.7	69.8	1.8
Oats	30	11.0	3.0	11.8	9.5	59.7	5.0
Rye	6	11.6	1.9	10.6	1.7	72.5	1.7
Wheat.							
Spring varieties	13	10.4	1.9	12.5	1.8	71.2	2.2
Winter varieties, all analyses	262	10.5	1.8	11.8	1.8	72.0	2.1
All varieties	310	10.5	1.8	11.9	1.8	71.9	2.1
Rice	10	12.4	.4	7.4	.2	79.2	.4
Buckwheat	8	12.6	2.0	10.0	8.7	64.5	2.2
Sunflower seed (whole)	2	8.6	2.6	16.3	29.9	21.4	21.2
Flaxseed	50	9.2	4.3	22.6	7.1	23.2	33.7
Cottonseed (whole, with hulls)	5	10.3	3.5	18.4	23.2	24.7	19.9
Cottonseed kernels (without hulls)	2	6.2	4.7	31.2	3.7	17.6	36.6
Cottonseed whole, roasted	2	6.1	5.5	16.8	20.4	23.5	27.7
Peanut kernel (witho't hulls)	7	7.5	2.4	27.9	7.0	15.6	39.5
Horse bean	1	11.3	3.8	26.6	7.2	50.1	1.0
Soja bean	8	10.8	4.7	34.0	4.8	28.8	16.9
Cow Pea	5	14.8	3.2	20.8	4.1	55.7	1.4
Mill Products.							
Corn meal	77	15.0	1.4	9.2	1.9	68.7	3.8
Corn and cob meal	7	15.1	1.5	8.5	6.6	64.8	3.5
Oatmeal	6	7.9	2.0	14.7	.9	67.4	7.1
Barley meal	3	11.9	2.6	10.5	6.5	66.3	2.2
Rye flour	4	13.1	.7	6.7	.4	78.3	.8
Wheat flour, all analyses	20	12.4	.5	10.8	.2	75.0	1.1
Buckwheat flour	4	14.6	1.0	6.9	.3	75.8	1.4
Ground linseed	2	8.1	4.7	21.6	7.3	27.9	30.4
Pea meal	2	10.5	2.6	20.2	14.4	51.1	1.2
Soja-bean meal	1	10.8	4.5	36.7	4.5	27.3	16.2
Ground corn and oats, equal parts		13.0	2.2	10.5	5.7	64.2	4.4
Waste Products.							
Corncob	18	10.7	1.4	2 4	30 1	54.9	.5
Hominy chops	12	11.1	2.5	9.8	3.8	64.5	8.3
Corn bran	5	9.1	1.3	9.0	12.7	62.2	5.8
Corn germ	3	10.7	4.0	9.8	4.1	64 0	7.4
Corn-germ meal	6	8.1	1.3	11.1	9.9	62.5	7.1

TABLE III.—Continued.

	Number of Analysis.	Percentage Compositiou.					
		Water.	Ash.	Protein.	Crude Fiber.	Nitrogen Free Extract.	Fat.
Grains and Other Seeds—Continued.							
Gluten Meal.							
Atlas1							
Cream		10.1	.8	33.7	1.7	51.1	2.6
Chicago*		12.3	1.3	36.5	1.4	45.8	2.7
King		7.4	.5	33.7	1.2	52.6	4.6
Gluten feed	11	7.8	1.1	24.0	5.3	51.2	10.6
Buffalo*		9.6	2.3	27 1	6.7	51.1	3.2
Peoria*	1	7.5	.8	19.8	8.2	51.1	12.6
Diamond or Rockford		8.9	.8	23.6	6.6	56.6	3.5
Chicago maize feed	3	9.1	.9	22.8	7.6	52.7	6.9
Glucose feed and glucose refuse	2	6.5	1.1	20.7	4.5	56.8	10.4
Dried starch feed and sugar feed	4	10.9	.9	19.7	4.7	54.8	9.0
Starch feed, wet	12	65.4	.3	6.1	5.1	22.0	3.1
Oat hulls		7.3	6.7	3.3	29.7	52.1	1.0
Oat feed	4	7.7	3.7	16.0	6.1	59.4	7.1
Barley screenings	2	12.2	3.6	12.3	7.3	61.8	2.8
Malt sprouts		5.0	6 4	27.6	10.9	47.1	3.0
Brewers' grains, wet	15	75.7	1.0	5.4	3.8	12.5	1.6
Brewers' grains, dried	3	8.2	3.6	19.9	11.0	51.7	5.6
Distillery grain, rye	1	7.3	2.4	18.2	14.5	43.0	14.6
Distillery, grain corn							
Grano gluten	1	5.8	2.8	31.1	12.0	33.4	14.9
Rye bran	7	11.6	3.6	14.7	3.5	63.8	2.8
Rye shorts	1	9.3	5.9	18.0	5.1	59.9	2.8
Wheat bran from spring.							
Wheat	10	11.5	5.4	16.1	8.0	54.5	4.5
Wheat bran from winter.							
Wheat	7	12.3	5.9	16.0	8.1	53.7	4.0
Wheat bran, all analyses	88	11.9	5.8	15.4	9.0	53.9	4.0
Wheat middlings		10.0	3.8	17.4	5.2	58.0	5.6
Wheat shorts	12	11.8	4.6	14.9	7.4	56.8	4.5
Wheat screenings	10	11.6	2.9	12.5	4.9	65.1	3.0
Rice bran	5	9.7	10.0	12.1	9.5	49.9	8.8
Rice hulls	3	8.2	13.2	3.6	35.7	38.6	.7
Rice polish	4	10.0	6.7	11.7	6.3	58.0	7.3
Buckwheat hulls	2	15.2	2.2	4.6	43.5	35.3	1.1
Buckwheat bran	2	10.5	3.0	12.4	31.9	38.8	3.3
Buckwheat middlings	3	13.2	4.8	28.9	4.1	41.9	7.1
Cottonseed meal		6.8	6.2	45.6	5.4	25.2	10.8
Cottonseed hulls	20	11.1	2.8	4.2	46.3	33.4	2.2
Linseed meal, old process		8.3	5.3	35.7	7.5	36.0	7.2
Linseed meal, new process		10.0	5.2	36.1	8.4	36.7	3.6
Peanut meal	2480	10.7	4.9	47.6	5.1	23.7	8.0

1 Refuge from distilleries.
* Included in above average.

TABLE III.—Continued.

	Number of Analysis.	Percentage Composition.					
		Water.	Ash.	Protein.	Crude Fiber.	Nitrogen Free Extract.	Fat.
Waste Products—Continued)							
Peanut hulls	5	9.0	3.4	6.6	64.3	15.1	1.6
Miscellaneous.							
Acorns		55.3	1.0	2.5	4.4	34.8	1.9
Apples		86.8	.4	.7	1.2	16.6	.4
Apple pomace	7	76.7	.5	1.4	3.9	16.2	1.3
Beet pulp	16	89.8	.6	.9	2.4	6.3	
Beet molasses	35	20.8	10.6	9.1?		59.5	
Cabbage	2	90.5	1.4	2.4	1.5	3.9	.4
Prickly comfrey	41	88.4	2.2	2.4	1.6	5.1	.3
Pumpkin (field)		90.9	.5	1.3	1.7	5.2	.4
Sugar beet leaves		88.0	2.4	2.6	2.2	4.4	.4
Dairy Products.							
Buttermilk	24	91.8	0.8	2.8		4.3	.3
Milk		87.3	.7	3.1		5.1	3.8
Skim milk	303	90.5	.8	3.5		4.8	.4
Whey		93.0	.8	.8		5.0	.4

TABLE IV.

Digestion Coefficients by Ruminants—Averages.

(From Jordan and Hall's Compilation O. E. S. Bulletin, No. 77, pages 82 to 87.)

Number of Experiments.		Digestion Coefficients.						
		Dry Matter, per cent.	Organic Matter, per cent.	Ash, per cent.	Protein, per cent.	Fiber, per cent.	Nitrogen Free Extract, per cent.	Fat, per cent.
	Meadow Grasses.							
3	Hungarian	67.2	68.6	52.2	64.3	71.2	67.9	65.7
4	Barnyard millet	66.6	67.0	59.5	61.5	66.5	68.3	64.3
1	Timothy	63.5	65.6	33.2	48.1	55.6	65.7	53.1
1	Timothy rowen	64.8	66.4	45.2	71.7	63.8	67.8	52.9
1	Pasture grass	68.7	70.0	49.7	65.5	74.3	72.5	54.7
1	Mixed-grass rowen	65.6	67.4	46.2	67.4	62.6	71.6	55.2
	Cereal Plants.							
2	Barley	65.9	67.5	54.4	71.8	60.8	71.2	59.9
8	Dent corn, immature	68.8	70.7	45.4	65.2	66.6	73.0	72.0
6	Dent corn, mature	66.6	68.5	19.4	52.3	51.6	74.7	77.0
14	Dent corn, all samples.	67.8	69.8	35.6	59.7	60.2	73.7	74.1
6	Sweet corn	71.1	72.2	55.3	64.0	62.9	76.6	75.6
3	Oats	59.5	60.9	53.4	71.8	52.8	62.6	69.2
1	Rye	73.4	75.3	55.8	79.4	79.2	70.1	74.5
2	Sorghum	67.3	69.0	42.4	46.8	59.0	74.6	74.2
	Clovers and Legumes							
1	Crimson clover	67.9	69.1	56.1	77.1	56.1	74.5	66.5
1	Red clover	66.1	68.1	55.0	67.0	52.6	77.6	64.5
1	Red clover rowen	59.3	60.8	43.4	61.9	52.5	65.3	60.8
1	Canada peas	68.4	71.3	42.3	82.0	62.4	71.0	52.4
2	Cow pea	68.3	74.1	22.8	75.6	59.6	80.6	59.4
4	Soy bean	59.8	64.5	18.9	75.1	47.0	73.2	54.1
1	Common vetch	61.8	65.7	17.3	71.4	44.2	76.1	58.6
3	Hairy vetch	70.3	73.1	45.1	82.8	61.1	76.3	71.6
	Mixed							
1	Barley and peas	53.4	60.2	46.2	77.2	43.5	61.4	59.7
4	Oats and peas	65.4	67.2	45.4	76.1	59.7	67.7	67.7
1	Vetch and oats	67.0	68.4	52.7	74.8	68.3	67.9	47.2
	Silage.							
	Maize.							
9	Dent corn	65.1	67.1	32.2	49.3	66.7	68.6	80.0
6	Flint corn	73.1	76.1	32.9	62.8	75.1	76.9	81.8
13	Dent corn, immature	65.6	67.4	34.3	51.3	70.6	67.4	80.2
10	Dent and flint corn, mature	70.8	73.6	30.3	56.0	70.0	76.1	82.4
1	Sweet corn	68.1	70.1	31.9	54.0	71.1	71.8	83.5
	Miscellaneous.							
1	Cow pea	59.6	63.4	30.3	57.5	52.0	72.5	62.6
1	Soy bean (steers)	49.8	53.8	28.0	55.3	42.9	61.2	48.9
1	Soy bean (goats)	59.0	59.3	56.7	75.7	54.8	52.0	71.9
1	Corn and soy bean	69.0	71.0		65.0	64.8	74.9	82.1

TABLE IV—Continued.

Number of Experiments.		Digestion Coefficients.						
		Dry Matter per cent.	Organic Matter per cent.	Ash per cent.	Protein per cent.	Fiber per cent.	Nitrogen Free Extract. per cent.	Fat per cent.
	Miscellaneous—Cont'd.							
1	Millet and soy bean....	58.8	59.9		58.4	69.4	59.2	72.2
1	Corn, horse beans and sunflower heads	65.6	67.8	41.1	62.7	60.1	72.4	76.7
1	Corn, horse beans and sunflower plants	65.5	69.3	25.6	58.0	65.3	73.7	74.1
	Dried Fodders.							
	Meadow Grasses.							
1	Black grass (Juncus bulbosus	59.5			63.0	60.5	57.0	41.5
1	Black grass (Juncus gerardi	53.4	52.1	69.0	54.3	57.4	49.0	45.7
2	Blue joint	54.3	55.8	29.4	63.4	54.5	55.9	44.7
1	Branch grass (Spartina stricta glabra	56.0			62.5	52.0	54.0	32.0
1	Branch grass (Distichlys spicata)	49.7	48.9	58.1	51.7	56.4	45.7	36.6
1	Chess or cheat.....	45.0	47.3	23.0	42.0	46.0	49.0	32.0
2	Crab grass	53.6	55.0	37.6		59.1	54.5	46.8
1	Fox grass (Spartina patens	54.8	54.5	58.2	59.3	57.4	53.1	36.4
1	Fox grass (Spartina juncea, etc.....	53.0			57.0	51.0	52.0	24.0
1	Flat sage	56.5	57.3	62.0	51.8	60.4	55.1	36.1
1	Hungarian grass	65.0	66.3	47.4	60.0	67.6	67.1	63.9
2	Johnson grass	56.5	58.3	30.5	41.4	65.7	56.9	38.4
1	Barnyard millet	57.4	56.8	63.1	63.7	61.6	51.6	46.3
1	Cat-tail millet	62.3	61.6	68.4	62.6	66.5	59.1	46.1
2	Orchard grass	56.6	57.8		59.5	60.4	55.4	53.8
2	Redtop	59.7	61.2	29.0	61.3	61.3	61.9	50.5
1	Redtop and sedge.....	46.0	48.5	10.1	37.2	55.7	45.6	49.0
17	Timothy	56.6	57.9	32.8	46.9	52.5	62.3	52.2
3	Timothy, before or in bloom	60.7	61.5	44.2	56.8	58.8	64.3	58.4
4	Timothy, past bloom...	53.4	54.5	30.3	45.1	47.1	60.4	51.9
1	Timothy rowen	62.2	64.4	56.4	68.0	66.5	63.4	49.5
2	Wild-oat grass	64.0	65.2	34.7	58.3	67.9	65.5	50.5
2	Witch grass	61.2	62.3	40.9	58.6	62.8	65.6	57.2
1	Black grass and red-top (cove mixture)	54.6	54.3	57.5	47.9	59.7	53.2	40.3
5	Mixed grasses	57.1	58.8		58.5	59.7	58.7	48.5
2	Pasture grass	72.6	73.2	51.8	73.4	76.1	74.2	67.3
1	Swale hay	39.0			34.0	33.0	46.0	44.0
1	High-grown salt hay....	53.0			63.0	50.0	53.0	47.0
1	Salt-hay mixture	56.4	54.9	69.8	42.6	60.7	54.7	29.7
2	Rowen hay	64.4	65.8	46.6	69.1	66.6	66.2	47.4

TABLE IV—Continued.

Number of Experiments.		Digestion Coefficients.						
		Dry Matter per cent.	Organic Matter per cent.	Ash per cent.	Protein per cent.	Fiber per cent.	Nitrogen Free Extract. per cent.	Fat per cent.
	Cereal Plants.							
1	Barley hay	61.2	62.3	44.8	65.2	61.7	63.3	40.5
17	Dent corn fodder	64.3	66.1	30.7	50.4	62.2	68.0	73.6
7	Flint corn fodder	68.6	71.7	42.6	60.0	74.9	70.3	71.4
13	Dent and flint corn fodders (immature)	63.9	65.7	37.2	51.7	66.0	66.2	72.2
10	Dent and flint corn fodders (mature)	68.2	70.7	30.6	56.1	55.8	72.2	73.9
3	Sweet corn fodder	67.2	69.8	35.6	64.1	73.8	68.2	73.6
5	Corn stover	57.2	59.1	32.6	35.9	64.2	57.9	70.4
3	New corn product	58.1	59.2	38.7	46.7	57.0	60.5	78.2
2	Topped corn fodder	57.4	62.3	3.8	38.7	71.0	57.9	67.4
1	Corn blades and husks	63.8	67.1	22.6	47.7	72.9	66.4	58.1
2	Corn leaves (pulled fodder)	59.8	63.3	26.8	48.4	67.5	63.0	59.9
1	Corn husks	72.0	74.2	16.0	29.5	79.5	75.0	32.5
1	Corn butts	66.5	69.4	11.5	21.0	73.5	69.0	79.5
1	Oat hay	49.3	50.1	34.6	54.2	43.5	52.0	61.9
1	Oat straw	50.3	52.0			57.6	53.2	38.3
	Sorghum fodder (pulled)	63.1	64.8	29.5	60.8	70.4	64.5	46.7
1	Sorghum bagasse	60.6	62.2	13.4	13.7	63.8	64.8	46.4
	Clovers.							
2	Alsike clover	62.3	63.2	52.2	66.1	53.5	70.7	50.2
4	Crimson clover	58.1	59.1	51.9	68.7	46.7	64.6	43.4
6	Red clover	57.4	59.7	29.1	58.0	54.2	64.4	55.2
2	Red clover rowen	58.0	59.1	45.8	64.8	47.4	62.8	59.8
1	White clover	66.0	66.6	58.5	73.2	60.6	69.5	50.6
	Legumes Other Than Clovers.							
3	Alfalfa	58.9	60.7	39.5	72.0	46.0	69.2	51.0
1	Cowpea vine	59.2	60.0	49.5	64.8	42.0	70.6	51.8
1	Peanut vine	59.9	63.1	20.4	63.3	51.9	69.5	65.9
1	Soy bean	62.4	63.9		71.1	60.8	68.8	29.2
1	Hairy vetch	69.4	71.8	42.2	82.3	61.1	72.9	70.3
	Miscellaneous.							
1	Buttercup hay	56.1	56.6	48.1	56.3	41.1	66.9	69.7
1	Whiteweed hay	57.8	58.3	52.0	58.4	45.5	66.7	62.0
2	Clover and timothy	54.6	53.2		42.3	49.6	57.5	54.0
1	Vetch and oats	58.1	58.7		59.7	66.0	54.2	18.6
	Grains and Seeds.							
5	Corn meal	89.4	93.9		67.9		94.6	92.1
2	Corn-and-cob meal	78.7	79.8		55.6	45.7	87.6	84.1
1	Rye meal	87.3	88.7		84.4		91.9	64.2
1	Pea meal	86.8	87.9	43.7	83.2	25.7	93.6	54.5
1	Soy bean meal	81.9	84.0		91.1	71.2	76.3	85.7
1	Cottonseed raw	66.1	65.8	43.3	67.8	75.5	49.6	87.1
1	Cottonseed, roasted	55.9	56.8		46.9	65.9	51.4	71.7

TABLE IV—Continued.

Number of Experiments.		Digestion Coefficients.						
		Dry Matter, per cent.	Organic Matter, per cent.	Ash, per cent.	Protein, per cent.	Fiber, per cent.	Nitrogen Free Extract, per cent.	Fat, per cent.
	By-Products. Cereals.							
1	Atlas meal	79.6	83.4		72.8	105.7	84.5	91.2
1	Cerealine feed	90.4	92.7		76.6	82.2	95.3	80.6
2	Corncobs	51.4			19.3	57.5	48.3	
1	Dried brewers' grains	61.6	65.4		79.3	52.6	57.8	91.1
5	Gluten feed	86.3	87.3		85.6	78.0	89.2	84.4
4	Gluten meal	89.7	90.4		88.2		89.8	94.4
1	H. O. Dairy feed	65.3	68.0		77.8	40.8	69.9	85.5
1	H. O. horse feed	70.1	72.6		74.4	35.2	78.7	84.0
1	Maize feed	87.1	87.1		85.5	82.5	87.9	91.5
1	Malt sprouts	67.1	67.2		80.2	32.9	68.1	104.6
1	Quaker oat feed	62.0	65.3		81.1	42.6	67.4	89.0
1	Victor corn-and-oat f'd	74.7	77.4		70.8	48.3	83.0	86.8
7	Wheat bran	62.3	65.7		77.8	28.6	69.4	69.0
1	Wheat bran and shorts	60.2	60.7	7.5	75.8	18.3	64.3	45.0
3	Wheat middlings	75.0	78.5		79.8	33.1	81.3	86.3
	Oil-Bearing Seeds.							
3	Cottonseed hulls	39.8	40.5	23.2		40.0	41.1	85.7
5	Cottonseed meal	73.7	76.1	23.7	88.4	55.5	60.6	93.3
1	Linseed meal, old process	78.7	81.2		88.8	57.0	77.6	88.6
2	Linseed meal, new process	79.2	81.8		85.2	80.4	86.1	96.6
	Miscellaneous.							
1	Peanut feed	32.1	32.8		70.6	11.7	49.1	89.7
1	Rice meal	73.8	81.6		61.9		92.3	91.1
	Roots.							
1	Mangolds	78.5	84.8	16.4	74.7	42.8	91.3	
1	Potatoes, raw	75.7	77.0		44.7		90.4	13.0
1	Potatoes, boiled	80.1	81.2		43.4		92.1	
1	Rutabagas	87.2	91.1	31.2	80.3	74.2	94.7	84.2
1	Sugar beets	94.5	98.7	31.9	91.3	100.7	99.9	49.9
1	Turnips	92.8	96.1	58.6	89.7	103.0	96.5	87.5

TABLE V.

This table is modeled after the tables in Bulletin No. 154, of the Cornell University Agricultural Experiment Station, but the figures have been calculated anew upon the basis of the computations given in Table 3 and the digestion coefficients given in Table 4 of this appendix.

Digestible Nutrients in the Standard Amounts of the Feeding Stuffs in Common Use in Maryland.

Kind and Amount of Food.	Pounds of Digestible Nutrients.				Nutritive ratio.
	Total dry matter.	Protein	Carbohydrates + (fat X 2.25)	Total	
GREEN FODDER.					
Fodder corn..... 1 lb.	.14	.010	.131	.141	1:13.1
Fodder corn..... 5 lbs.....	.71	.050	.656	.706	
Fodder corn.....15 lbs.....	2.13	.152	1.968	2.120	
Fodder corn.....20 lbs.....	2.84	.202	2.624	2.826	
Fodder corn.....25 lbs.....	3.55	.253	3.280	3.533	
Fodder corn.....30 lbs.....	4.27	.304	3.936	4.240	
Fodder corn.....35 lbs.....	4.98	.355	4.592	4.947	
Fodder corn.....40 lbs.....	5.69	.405	5.249	5.654	
Alfalfa ..... 1 lb.	.18	.083	.129	.167	1:3.3
Alfalfa ..... 5 lbs.....	.90	.194	.645	.839	
Alfalfa .....15 lbs.....	2.70	.583	1.935	2.518	
Alfalfa .....20 lbs.....	3.60	.777	2.580	3.357	
Alfalfa .....25 lbs.....	4.51	.972	3.225	4.197	
Alfalfa .....30 lbs.....	5.41	1.166	3.870	5.036	
Alfalfa .....35 lbs.....	6.31	1.360	4.515	5.875	
Alfalfa .....40 lbs.....	7.21	1.555	5.161	6.716	
Cow peas.....1 lb.	.11	.018	.091	.109	1:5
Cow peas..... 5 lbs.....	.56	.090	.455	.545	
Cow peas.....15 lbs.....	1.68	.272	1.367	1.639	
Cow peas.....20 lbs.....	2.24	.362	1.823	2.185	
Cow peas.....25 lbs.....	2.80	.543	2.279	2.732	
Cow peas.....30 lbs.....	3.36	.544	2.735	3.279	
Cow peas.....35 lbs.....	3.92	.634	3.190	3.824	
Cow peas.....40 lbs.....	4.48	.725	3.646	4.371	
Crimson clover..... 1 lb.	.12	.023	.103	.126	1:4.4
Crimson clover..... 5 lbs.....	.64	.119	.516	.635	
Crimson clover.....15 lbs.....	1.94	.358	1.458	1.906	
Crimson clover..... 20 lbs.....	2.59	.478	2.064	2.542	
Crimson clover.....25 lbs.....	3.23	.297	2.580	3.177	
Crimson clover.....30 lbs.....	3.88	.717	3.097	3.814	
Crimson clover.....35 lbs.....	4.53	.836	3.613	4.449	
Crimson clover.....40 lbs.....	5.18	.956	4.129	5.085	
Red clover..... 1 lb.	.19	.029	.163	.192	1:5.6

TABLE V.—(Continued).

Kind and Amount of Food.	Pounds of Digestible Nutrients.				Nutritive ratio.
	Total dry matter.	Protein.	Carbohydrates + (fat X 2.25)	Total	
GREEN FODDER—Continued.	.95	.147	.816	.963	
Red clover..... 5 lbs.....	2.87	.442	2.449	2.891	
Red clover.....15 lbs.....	3.86	.589	3.226	3.815	
Red clover.....20 lbs.....	4.82	.737	4.083	4.820	
Red clover.....25 lbs.....					
Red clover.....30 lbs.....	5.79	.884	4.899	5.783	
Red clover.....35 lbs.....	6.75	1.031	5.716	6.747	
Red clover.....40 lbs.....	7.72	1.179	6.533	7.712	
Rye ..... 1 lb.	.17	.018	.149	.167	1:8.2
Rye ..... 5 lbs.....	.85	.093	.747	.840	
Rye .....15 lbs.....	2.67	.280	2.243	2.523	
Rye .....20 lbs.....	3.53	.373	2.991	3.364	
Rye ..... 25 lbs.....	4.39	.466	3.739	4.205	
Rye .....30 lbs.....	5.25	.560	4.487	5.047	
Rye .....35 lbs.....	6.11	.653	5.235	5.888	
Rye .....40 lbs.....	6.97	.746	5.983	6.729	
SILAGE.					
Corn silage (mature).... 1 lb.	.13	.008	.129	.137	1:16.1
Corn silage (mature).... 5 lbs.....	.69	.041	.649	.690	
Corn silage (mature)....15 lbs.....	2.07	.125	1.947	1.072	
Corn silage (mature)....20 lbs.....	2.76	.167	2.595	2.762	
Corn silage (mature)....25 lbs.....	3.45	.209	3.244	3.453	
Corn silage (mature)....30 lbs.....	4.14	.251	3.893	4.144	
Corn silage (mature)....35 lbs.....	4.83	.293	4.542	4.535	
Corn silage (mature)....40 lbs.....	5.52	.335	5.191	5.526	
Corn silage (mature)....45 lbs.....	6.21	.377	5.840	6.217	
Corn silage (mature)....50 lbs.....	6.90	.417	6.489	6.908	
Cow peas, silage..... 1 lb.	.12	.015	.076	.091	1:5.2
Cow peas, silage..... 5 lbs.....	.61	.077	.380	.457	
Cow peas, silage.....15 lbs.....	1.85	.232	1.140	1.372	
Cow peas, silage.....20 lbs.....	2.46	.310	1.520	1.830	
Cow peas, silage.....25 lbs.....	3.08	.388	1.900	2.288	
Cow peas, silage.....30 lbs.....	3.70	.465	2.280	2.745	
Cow peas, silage.....35 lbs.....	4.31	.545	2.660	3.205	
Cow peas, silage.....40 lbs.....	4.93	.623	3.040	3.663	
Cow peas, silage.....45 lbs.....	5.55	.700	3.420	4.120	
Cow peas, silage.....50 lbs.....	6.16	.778	3.800	4.578	
Soja bean silage..... 1 lb.	.12	.022	.106	.128	1:4.8
Soja bean silage..... 5 lbs.....	.64	.113	.534	.647	
Soja bean silage.....15 lbs.....	1.92	.340	1.604	1.944	
Soja bean silage.....20 lbs.....	2.56	.453	2.138	2.591	
Soja bean silage.....25 lbs.....	3.21	.566	2.673	3.239	
Soja bean silage.....30 lbs.....	3.85	.680	3.208	3.888	
Soja bean silage.....35 lbs.....	4.49	.793	3.743	4.536	
Soja bean silage.....40 lbs.....	5.13	.906	4.277	5.183	

TABLE V.—(Continued).

Kind and Amount of Food.	Pounds of Digestible Nutrients.				Nutritive ratio.
	Total dry matter.	Protein.	Carbohydrates + (fat X 2.25)	Total.	
SILAGE—Continued.					
Soja bean silage.....45 lbs.....	5.78	1.020	4.812	5.832	
Soja bean silage.....50 lbs.....	6.32	1.138	5.347	6.485	
HAY AND STRAW.					
Alfalfa hay..... 1 lb.	.53	.102	.429	.531	1:4.5
Alfalfa hay..... 3 lbs.....	1.61	.328	1.289	1.617	
Alfalfa hay..... 5 lbs.....	2.69	.534	2.148	2.632	
Alfalfa hay..... 7 lbs.....	3.77	.740	2.578	3.218	
Alfalfa hay..... 8 lbs.....	4.31	.843	3.008	3.851	
Alfalfa hay..... 9 lbs.....	4.85	.946	3.437	4.403	
Alfalfa hay.....12 lbs.....	6.47	1.275	4.727	6.002	
Alfalfa hay.....15 lbs.....	8.09	1.604	6.016	7.620	
Alfalfa hay.....18 lbs.....	9.71	1.933	7.305	9.238	
Alfalfa hay.....20 lbs.....	10.79	2.139	8.594	10.733	
Corn stover..... 1 lb.	.34	.013	.326	.339	1:25
Corn stover..... 3 lbs.....	1.70	.068	1.631	1.699	
Corn stover..... 8 lbs.....	2.72	.109	2.610	2.719	
Corn stover.....12 lbs.....	4.08	.163	3.915	4.078	
Corn stover.....15 lbs.....	5.10	.204	4.894	5.098	
Corn stover.....18 lbs.....	6.12	.245	5.873	6.118	
Corn stover.....20 lbs.....	6.80	.272	6.525	6.797	
Cow-pea hay..... 1 lb.	.52	.106	.407	.513	1:3.8
Cow-pea hay..... 3 lbs.....	1.58	.319	1.223	1.542	
Cow-pea hay..... 5 lbs.....	2.64	.532	2.039	2.671	
Cow-pea hay..... 7 lbs.....	3.70	.745	2.955	3.700	
Cow-pea hay..... 8 lbs.....	4.22	.852	3.363	4.215	
Cow-pea hay..... 9 lbs.....	4.75	.959	3.771	4.730	
Cow-pea hay.....12 lbs.....	6.34	1.278	4.994	5.282	
Cow-pea hay.....15 lbs.....	7.92	1.598	6.218	7.816	
Cow-pea hay.....18 lbs.....	9.51	1.917	7.442	9.359	
Cow-pea hay.....20 lbs.....	10.57	2.130	8.258	10.388	
Crimson clover hay..... 1 lb.	.52	.104	.398	.493	1:3.7
Crimson clover hay..... 3 lbs.....	1.57	313	1.169	1.482	
Crimson clover hay..... 5 lbs.....	2.62	.522	1.949	2.471	
Crimson clover hay..... 7 lbs.....	3.67	.730	2.728	3.458	
Crimson clover hay..... 8 lbs.....	4.20	.833	3.118	3.953	
Crimson clover hay..... 9 lbs.....	4.72	.939	3.508	4.447	
Crimson clover hay.....12 lbs.....	6.30	1.253	4.677	5.930	
Crimson clover hay.....15 lbs.....	7.87	1.566	5.847	7.413	
Crimson clover hay.....18 lbs.....	9.45	1.879	7.016	8.895	
Crimson clover hay.....20 lbs.....	10.50	2.088	7.796	9.884	
Oat hay ..... 1 lb.	.41	.050	.307	.357	1:6.1
Oat hay ..... 3 lbs.....	1.25	.151	.923	1.074	
Oat hay ..... 5 lbs.....	2.09	.252	1.539	1.791	
Oat hay ..... 7 lbs.....	2.93	.352	2.154	2.506	

TABLE V.—(Continued).

Kind and Amount of Food.	Pounds of Digestible Nutrients.				Nutritive ratio.
	Total dry matter.	Protein.	Carbo-hydrates + (fat X 2.25)	Total.	
HAY AND STRAW—Continued.					
Oat hay ..... 8 lbs.....	3.35	.403	2.462	2.865	
Oat hay ..... 9 lbs.....	3.77	.453	2.770	3.223	
Oat hay .....12 lbs.....	5.02	.604	3.694	4.298	
Oat hay .....15 lbs.....	6.27	.756	4.617	5.373	
Oat hay .....18 lbs.....	7.53	.907	5.541	6.448	
Oat hay .....20 lbs.....	8.39	1.008	6.157	7.165	
Orchard grass hay..... 1 lb.	.50	.048	.454	.502	1:9.4
Orchard grass hay..... 3 lbs.....	1.50	.144	1.362	1.506	
Orchard grass hay..... 5 lbs.....	2.50	.240	2.271	2.511	
Orchard grass hay..... 7 lbs.....	3.50	.337	3.180	3.517	
Orchard grass hay..... 8 lbs.....	4.00	.385	3.634	4.019	
Orchard grass hay..... 9 lbs.....	4.50	.433	4.088	4.521	
Orchard grass hay.....12 lbs.....	6.01	.578	5.451	6.029	
Orchard grass hay.....15 lbs.....	7.51	.722	6.814	7.536	
Orchard grass hay.....18 lbs.....	9.01	.867	8.177	9.044	
Orchard grass hay.....20 lbs.....	10.01	.963	9.086	10.049	
Red clover hay..... 1 lb.	.48	.071	.420	.491	1:5.6
Red clover hay..... 3 lbs.....	1.46	.214	1.262	1.476	
Red clover hay..... 5 lbs.....	2.43	.356	2.103	2.459	
Red clover hay..... 7 lbs.....	3.41	4.99	2.945	3.444	
Red clover hay..... 8 lbs.....	3.89	.570	3.366	3.936	
Red clover hay..... 9 lbs.....	4.38	.642	3.786	4.428	
Red clover hay.....12 lbs.....	5.84	.856	5.049	5.905	
Red clover hay.....15 lbs.....	7.30	1.070	6.311	7.381	
Red clover hay.....18 lbs.....	8.76	1.926	7.573	9.499	
Red clover hay.....20 lbs.....	9.74	2.068	8.415	10.483	
Timothy ..... 1 lb.	.55	.028	.485	.513	1:17.3
Timothy ..... 3 lbs.....	1.65	.084	1.456	1.540	
Timothy ..... 5 lbs.....	2.75	.140	2.428	2.568	
Timothy ..... 7 lbs.....	3.85	.197	3.399	3.596	
Timothy ..... 8 lbs.....	4.40	.226	3.885	4.111	
Timothy ..... 9 lbs.....	4.96	.254	4.370	4.624	
Timothy .....12 lbs.....	6.61	.338	5.827	6.195	
Timothy .....15 lbs.....	8.26	.422	7.284	7.706	
Timothy .....18 lbs.....	9.92	.506	8.741	9.246	
Timothy .....20 lbs.....	11.02	.563	9.713	10.176	
GRAIN.					
*Barley ..... 1 lb.	.76	.86	.684	.770	1:7.9
Barley ..... 2 lbs.....	1.53	.173	1.368	1.541	
Barley ..... 3 lbs.....	2.29	.260	2.052	2.312	
Barley ..... 4 lbs.....	3.06	.347	2.736	3.083	
Barley ..... 5 lbs.....	3.83	.434	3.420	3.854	
Barley ..... 6 lbs.....	4.59	.520	4.104	4.624	

*Digestion coefficient of fiber taken from oats.

TABLE V.—(Continued).

Kind and Amount of Food.	Pounds of Digestible Nutrients.				Nutritive ratio.
	Total dry matter.	Protein.	Carbohydrates + (fat X 2.25)	Protein.	
GRAIN—Continued.					
†Corn (Dent) ..... 1 lb.	.79	.069	.685	.754	1:9.9
Corn (Dent) ..... 2 lbs.....	1.59	.139	1.370	1.509	
Corn (Dent) ..... 3 lbs.....	2.39	.209	2.055	2.264	
Corn (Dent) ..... 4 lbs.....	3.19	.279	2.740	3.019	
Corn (Dent) ..... 5 lbs.....	3.99	.349	3.425	3.774	
Corn (Dent) ..... 6 lbs.....	4.79	.419	4.110	4.529	
Corn (Dent) ..... 7 lbs.....	5.59	.489	4.796	5.285	
Corn (Dent) ..... 8 lbs.....	6.39	.559	5.481	6.140	
Corn (Dent) ..... 9 lbs.....	7.19	.629	6.166	6.795	
Oats ..... 1 lb.	.63	.092	.577	.669	1:6.2
Oats ..... 2 lbs.....	1.26	.184	1.155	1.339	
Oats ..... 3 lbs.....	1.89	.276	1.733	2.009	
Oats ..... 4 lbs.....	2.52	.368	2.311	2.679	
Oats ..... 5 lbs.....	3.15	.460	2.888	3.348	
Oats ..... 6 lbs.....	3.79	.552	3.466	4.018	
Oats ..... 7 lbs.....	4.42	.644	4.044	4.688	
Oats ..... 8 lbs.....	5.05	.736	4.622	5.358	
Oats ..... 9 lbs.....	5.68	.828	5.199	6.027	
Oats .....12 lbs.....	7.58	1.104	6.933	8.037	
Oats .....15 lbs.....	9.47	1.380	8.666	10.046	
†Rye ..... 1 lb.	.77	.089	.680	.769	1:7.6
Rye ..... 2 lbs.....	1.54	.179	1.361	1.540	
Rye ..... 3 lbs.....	2.31	.269	2.041	2.310	
Rye ..... 4 lbs.....	3.08	.358	2.722	3.080	
Rye ..... 5 lbs.....	3.85	.448	3.403	3.851	
Rye ..... 6 lbs.....	4.63	.537	4.083	4.620	
MILL AND BY-PRODUCTS.					
*Corn-and-cob meal..... 1 lb.	.66	.047	.664	.711	1:14.1
Corn-and-cob meal..... 2 lbs.....	1.33	.094	1.328	1.422	
Corn-and-cob meal..... 3 lbs.....	2.00	.141	1.992	2.133	
Corn-and-cob meal..... 4 lbs.....	2.67	.189	2.656	2.845	
Corn-and-cob meal..... 5 lbs.....	3.34	.236	3.320	3.556	
Corn-and-cob meal..... 6 lbs.....	4.00	.283	3.984	4.267	
Corn-and-cob meal..... 7 lbs.....	4.67	.330	4.648	4.978	
Corn-and-cob meal..... 8 lbs.....	5.34	.378	5.312	5.690	
Corn-and-cob meal..... 9 lbs.....	6.01	.425	5.976	6.401	
Corn-and-cob meal.....12 lbs.....	8.01	.567	7.968	8.535	
Hominy chops ..... 1 lb.	.79	.066	.797	.863	1:12
Hominy chops ..... 2 lbs.....	1.58	.133	1.594	1.727	
Hominy chops ..... 3 lbs.....	2.38	.200	2.392	2.592	
Hominy chops ..... 4 lbs.....	3.17	.267	3.189	3.456	
Hominy chops ..... 5 lbs.....	3.97	.333	3.986	4.319	

†Used digestion coefficient of fiber as obtained from digestion by horses.
†Used digestion coefficient of fiber as obtained from digestion by horses.
*Digestion coefficients taken from those of corn meal.

TABLE V.—(Continued.)

Kind and Amount of Food.	Pounds of Digestible Nutrients.				Nutritive ratio.
	Total dry matter.	Protein.	Carbo-hydrates + (fat X 2.25)	Total.	
MILL AND BY-PRODUCTS—Con.					
Hominy chops ..... 6 lbs.....	4.76	.400	4.784	5.184	
Hominy chops ..... 7 lbs.....	5.56	.466	5.581	6.047	
Hominy chops ..... 8 lbs.....	6.36	.533	6.378	6.911	
Hominy chops ..... 9 lbs.....	7.15	.599	7.176	7.775	
Brewers' grains, dry..... 1 lb.	.56	.157	.471	.628	1:3.
Brewers' grains, dry..... 2 lbs.....	1.13	.315	.942	1.257	
Brewers' grains, dry..... 3 lbs.....	1.69	.473	1.414	1.887	
Brewers' grains, dry..... 4 lbs.....	2.26	.631	1.885	2.516	
Brewers' grains, dry..... 5 lbs.....	2.82	.789	2.357	4.146	
Brewers' grains, dry..... 6 lbs.....	3.39	.946	2.828	3.774	
Brewers' grains, dry..... 7 lbs.....	3.95	1.104	3.300	4.404	
Brewers' grains, dry..... 8 lbs.....	4.52	1.262	3.771	5.033	
Brewers' grains, dry..... 9 lbs.....	5.08	1.420	4.243	5.663	
Brewers' grains, wet..... 1 lb.	.14	.042	.125	.167	1:3
Brewers' grains, wet..... 2 lbs.....	.29	.085	.250	.355	
Brewers' grains, wet..... 3 lbs.....	.44	.128	.376	.504	
Brewers' grains, wet..... 4 lbs.....	.59	.171	.501	.672	
Brewers' grains, wet..... 5 lbs.....	.74	.214	.626	.840	
Brewers' grains, wet..... 6 lbs.....	.89	.256	.751	1.007	
Brewers' grains, wet..... 7 lbs.....	1.02	.299	.876	1.175	
Brewers' grains, wet..... 8 lbs.....	1.17	.342	1.001	1.343	
Brewers' grains, wet..... 9 lbs.....	1.32	.428	1.126	1.554	
Brewers' grains, wet.....11 lbs.....	1.62	.513	1.376	1.889	
Brewers' grains, wet.....12 lbs.....	1.77	.556	1.501	2.057	
Brewers' grains, wet.....15 lbs.....	2.22	.685	1.877	2.562	
*Buckwheat middlings... 1 lb.	.65	.230	.492	.722	1:2.1
Buckwheat middlings... 2 lbs.....	1.30	.461	.984	1.445	
Buckwheat middlings... 3 lbs.....	1.95	.692	1.476	2.168	
Buckwheat middlings... 4 lbs.....	2.60	.922	1.968	2.890	
Buckwheat middlings... 5 lbs.....	3.25	1.153	2.461	3.614	
Buckwheat middlings... 6 lbs.....	3.90	1.384	2.953	4.337	
Buckwheat middlings... 7 lbs.....	4.55	1.615	3.445	5.060	
Buckwheat middlings... 8 lbs.....	5.20	1.845	3.937	5.782	
Buckwheat middlings... 9 lbs.....	5.85	2.076	4.429	6.505	
Cottonseed meal ..... 1 lb.	.68	.403	.341	.744	1: .8
Cottonseed meal ..... 2 lbs.....	1.37	.806	.683	1.489	
Cottonseed meal ..... 3 lbs.....	2.06	1.209	1.204	2.233	
Cottonseed meal ..... 4 lbs.....	2.74	1.612	1.366	2.978	
Cottonseed meal ..... 5 lbs.....	3.43	2.015	1.707	3.722	
Cottonseed meal ..... 6 lbs.....	4.12	2.418	2.049	4.567	
Cottonseed meal ..... 7 lbs.....	4.80	2.821	2.391	5.212	
Cottonseed meal ..... 8 lbs.....	5.49	3.224	2.732	5.956	
Cottonseed meal ..... 9 lbs.....	6.18	3.627	3.074	6.701	

*Digestion coefficients taken from those of wheat middling.

TABLE V—(Continued).

Kinds and Amount of Food.	Pounds of Digestible Nutrients.				Nutritive ratio.
	Total dry matter.	Protein.	Carbohydrates + (fat X 2.25)	Total.	
MILL FEED AND BY-PRODUCTS (Continued).					
Gluten feed ..... 1 lb.	.79	.205	.699	.904	1:3.4
Gluten feed ..... 2 lbs.....	1 59	.410	1.398	1.806	
Gluten feed ..... 3 lbs.....	2.38	.616	2.098	2.714	
Gluten feed ..... 4 lbs.....	3.18	.821	2.797	3.618	
Gluten feed ..... 5 lbs.....	3.97	1.027	3.496	4.523	
Gluten feed ..... 6 lbs.....	4.77	1.232	4.196	5.428	
Gluten feed ..... 7 lbs.....	5.56	1.438	4.895	6.333	
Gluten feed ..... 8 lbs.....	6.36	1.643	5.594	7.237	
Gluten meal ..... 1 lb.	.78	.321	.474	.795	1:1.4
Gluten meal ..... 2 lbs.....	1.57	.643	.948	1.591	
Gluten meal ..... 3 lbs.....	2.36	.965	1.422	2.387	
Gluten meal ..... 4 lbs.....	3.14	1.287	1.896	2.183	
Gluten meal ..... 5 lbs.....	3.93	1.609	2.371	3.980	
Gluten meal ..... 6 lbs.....	4.72	1.931	2.845	4.776	
Gluten meal ..... 7 lbs.....	5.50	2.253	3.319	5.572	
Gluten meal ..... 8 lbs.....	6.29	2.575	3.793	6.368	
Linseed meal:					
(New process) 1 lb.	.71	.307	.507	.814	1:1.9
(New process) 2 lbs.....	1.42	.615	1.014	1.629	
(New process) 3 lbs.....	2.13	9.22	1.521	2.443	
(New process) 4 lbs.....	2.85	1.229	2.028	3.257	
(New process) 5 lbs.....	3.56	1.536	2.535	4.071	
(New process) 6 lbs.....	4.27	1.844	3.042	4.886	
(New process) 7 lbs.....	4.99	2.152	3.550	5.702	
Linseed meal:					
(Old process). 1 lb.	.72	.317	.461	.778	1:1.4
(Old process). 2 lbs.....	1.44	.634	.922	1.556	
(Old process). 3 lbs.....	2.16	.951	1.383	2.334	
(Old process). 4 lbs.....	2.88	1.268	1.844	3.112	
(Old process). 5 lbs.....	4.33	1.892	2.766	4.658	
(Old process). 6 lbs.....	4.33	1.892	2.766	4.658	
(Old process). 7 lbs.....	5.05	2.209	3.227	5.436	
Malt sprouts ..... 1 lb.	.63	.221	.427	. 648	1:1.9
Malt sprouts ..... 2 lbs.....	1.27	.442	.854	1.296	
Malt sprouts ..... 3 lbs.....	1.91	.664	1.281	1.945	
Malt sprouts ..... 4 lbs.....	2.54	.885	1.708	2.593	
Malt sprouts ..... 5 lbs.....	3.18	1.106	2.136	3.242	
Malt sprouts ..... 6 lbs.....	3.82	1.328	2.563	3.891	
Malt sprouts ..... 7 lbs.....	4.46	1.549	2.990	4.539	
Malt sprouts ..... 8 lbs.....	5.09	1.770	3.417	5.187	
Malt sprouts ..... 9 lbs.....	5.73	1.992	3.844	5.836	
Wheat bran ..... 1 lb.	.54	.119	.480	.599	1:4

TABLE V—(Continued).

Kinds and Amount of Food.	Pounds of Digestible Nutrients.				Nutritive ratio.
	Total dry Matter.	Protein	Carbohydrates, + (fat X 2.25)	Total.	
MILL FEED AND BY-PRODUCTS (Continued).					
Wheat bran ..... 2 lbs.....	1.09	.239	.961	1.200	
Wheat bran ..... 3 lbs.....	1.64	.359	1.442	1.801	
Wheat bran ..... 4 lbs.....	2.19	.479	1.923	2.402	
Wheat bran ..... 5 lbs.....	2.74	.599	2.404	3.003	
Wheat bran ..... 6 lbs.....	3.29	.718	2.884	3.602	
Wheat bran ..... 7 lbs.....	3.84	.838	3.365	4.203	
Wheat bran ..... 8 lbs.....	4.39	.958	3.846	4.704	
Wheat bran ..... 9 lbs.....	4.93	1.078	4.327	5.405	
Wheat middlings ..... 1 lb.	.67	.138	.587	.725	1:4.2
Wheat middlings ..... 2 lbs.....	1.35	.277	1.117	1.394	
Wheat middlings ..... 3 lbs.....	2.02	.416	1.762	2.178	
Wheat middlings ..... 4 lbs.....	2.70	.555	2.349	2.904	
Wheat middlings ..... 5 lbs.....	3.37	.694	2.937	3.631	
Wheat middlings ..... 6 lbs.....	4.05	.833	3.514	4.347	
Wheat middlings ..... 7 lbs.....	4.72	.971	4.102	5.073	
Wheat middlings ..... 8 lbs.....	5.40	1.110	4.689	5.799	
Wheat middlings ..... 9 lbs.....	6.07	1.249	5.277	6.526	
MISCELLANEOUS.					
Skim milk ..... 1 lb.	.12	.029	.057	.086	1:2
Skim milk ..... 5 lbs.....	.62	.145	.285	.430	
Skim milk ..... 8 lbs.....	.99	.233	.456	.689	
Skim milk .....12 lbs.....	1.49	.349	.684	1.033	
Skim milk .....15 lbs.....	1.86	.437	.855	1.292	
Skim milk .....20 lbs.....	2.48	.582	1.140	1.722	
Skim milk .....25 lbs.....	3.11	.728	1.426	2.154	
Skim milk .....30 lbs.....	3.73	.874	1.711	2.585	
Buttermilk ..... 1 lb.	.07	.026	.044	.070	1:1.7
Buttermilk ..... 5 lbs.....	.38	.134	.224	.358	
Buttermilk ..... 8 lbs.....	.61	.215	.359	.574	
Buttermilk .....12 lbs.....	.92	.322	.539	.861	
Buttermilk .....15 lbs.....	1.16	.403	.674	1.077	
Buttermilk .....20 lbs.....	1.54	.537	.899	1.436	
Buttermilk .....25 lbs.....	1.93	.672	1.122	1.794	
Buttermilk .....30 lbs.....	2.32	.806	1.347	2.153	

TABLE VI.

Fertilizing Constituents of American Feeding Stuffs and Manurial Value per ton.

From the Handbook of Experiment Station Work, except as otherwise noted. Nitrogen valued at 12 cents per pound, phosphoric acid at 4 cents, and potash at 5 cents.

	Pounds in 100 pounds			Value in Dollars per ton.
	Nitrogen.	Phosphoric Acid.	Potash.	
GREEN FODDER.				
Corn—dent, cut before glazing	0.41	0.15	0.33	1.43
Cow pea	0.27	0.10	0.31	1.04
Crimson clover (just heading*)	0.40	0.12	0.34	1.40
Crimson clover (full bloom*)	0.51	0.12	0.35	1.67
Orchard grass (in bloom)	0.43	0.16	0.76	1.92
Pasture grass*	0.75	0.19	0.60	2.55
Red clover	0.53	0.13	0.46	1.84
Rye	0.33	0.15	0.73	.64
Soja bean	0.29	0.15	0.53	1.35
SILAGE.				
Corn silage—average of all analyses	0.28	0.11	0.37	1.13
HAY, STRAW, ETC.				
Alfalfa hay	2.19	0.51	1.68	7.34
Barley straw	1.31	0.30	2.09	5.47
Buckwheat hulls	0.49	0.07	0.52	1.74
Corn forage, field cured	1.76	0.54	0.89	5.55
Corn stover, field cured	1.04	0.29	1.40	4.13
Clover hay, red	2.07	0.38	2.20	7.47
Hungarian millet hay	1.20	0.35	1.30	4.46
Mixed meadow grass hay	1.02	0.26	1.48	4.14
Mixed hay	1.67	0.46	1.55	5.93
Oat straw	.62	0.20	1.24	2.89
Orchard grass hay	1.31	0.41	1.88	5.35
Red-top hay	.15	0.36	1.02	4.07
Rye straw	0.46	0.28	0.79	2.12
Timothy hay	1.26	0.53	0.90	4.35
Wheat straw	0.59	0.12	0.51	2.02
Wheat chaff	0.79	0.70	0.42	2.88
ROOTS AND TUBERS.				
Carrots	0.15	0.09	0.51	.94
Mangel wurzels	0.19	0.09	0.38	.91
Potatoes	0.21	0.07	0.29	.85
Rutabagas	0.19	0.12	0.49	1.04
Sugar beets	0.22	0.10	0.48	1.09
Turnips	0.18	0.10	0.39	0.90
GRAIN.				
Barley	1.51	0.79	0.48	4.74
Buckwheat	1.44	0.44	0.21	4.02

*Report N. J. Experiment Station, 1894.

TABLE VI.—(Continued).

	Pounds in 100 pounds.			
	Nitrogen.	Phosphoric Acid.	Potash.	Value in Dollars per ton.
GRAIN—Continued.				
Corn—dent*	1.65	0.70	0.40	4.92
Corn, sweet*	1.82	0.72	0.41	5.36
Oats	2.06	0.82	0.62	6.22
Peas, Canada	3.08	0.82	0.99	9.04
Rye	1.76	0.82	0.54	5.42
Wheat, winter	2.36	0.89	0.61	6.99
MILL AND BY-PRODUCTS.				
Barley meal	1.55	0.66	0.34	4.59
Buckwheat middlings†	4.62	1.73	1.56	14.03
Corn meal	1.58	0.63	0.40	4.70
Corn-and-cob meal	1.41	0.57	0.47	4.31
Hominy chop	1.63	0.98	0.49	5.18
Pea meal	3.08	0.82	0.99	9.04
Rye bran	2.32	2.28	1.40	8.79
Wheat bran	2.67	2.89	1.61	10.33
Wheat middlings	2.63	0.95	0.63	7.70
Wheat shorts*	2.42	1.38	0.65	7.56
Apple pomace	0.23	0.02	0.13	.70
Brewers' grains, dried	3.05	1.26	1.55	9.88
Brewers' grains, wet	0.89	0.31	0.05	2.43
Corn cobs	0.50	0.06	0.60	1.85
Cottonseed hulls	0.75	0.18	1.08	3.02
Cottonseed meal	6.64	2.68	1.79	19.87
Gluten meal	5.03	0.33	0.05	12.39
Gluten feed	3.44	0.38	0.07	8.63
Germ meal	3.48	6.16	2.91	16.19
Linseed meal, new process	5.78	1.83	1.39	16.73
Linseed meal, old process	5.43	1.66	1.37	15.73
Malt sprouts	3.55	1.43	1.63	11.29
DAIRY PRODUCTS.				
Butter	0.12	0.04	0.04	.36
Buttermilk	0.48	0.17	0.16	1.45
Cheese	3.93	0.60	0.12	10.03
Cream	0.40	0.15	0.13	1.21
Milk	0.53	0.19	0.18	1.60
Skim milk	0.56	0.20	0.19	1.69
Whey	0.15	0.14	0.18	.65

*Report N. J. Experiment Station, 1894.

†The Nitrogen from Jenkins & Wintons compilation of Am. Feeding Stuffs, (O. E. S. Bul. No. 11). The phosphoric acid and potash computed on the assumption that the total ash has the same composition as that found by Wolff for buckwheat bran.

INDEX.

A

B

C

D

E

F

G

H

I

L

M

N

O

P

R

S

T

U

V

W